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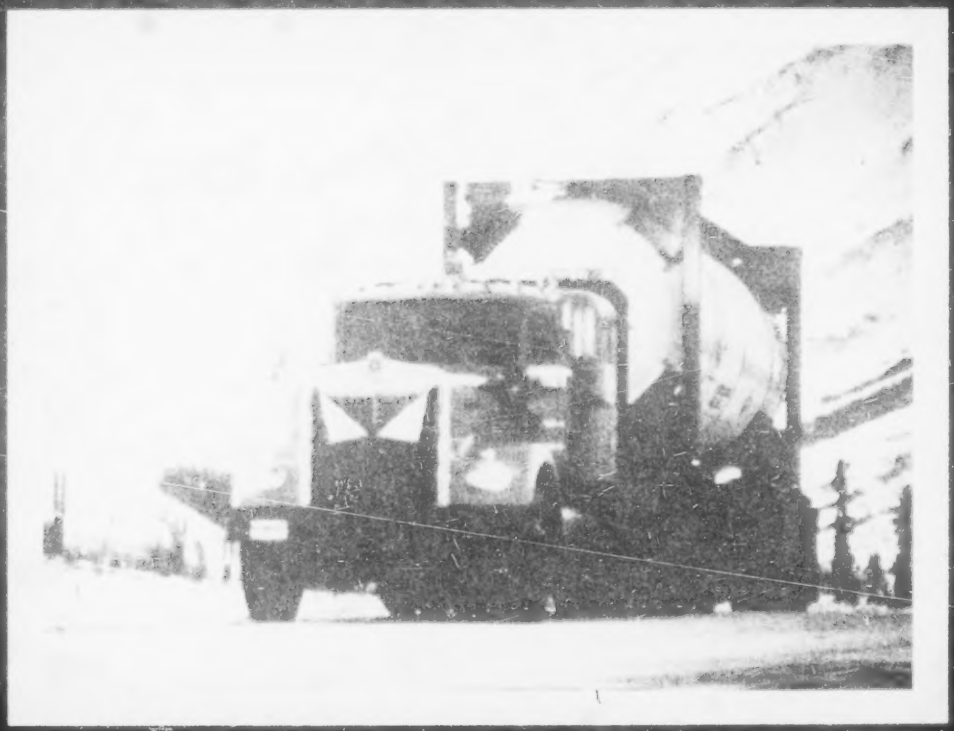
Transportation of Hazardous Materials

Summary



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Office of Technology Assessment
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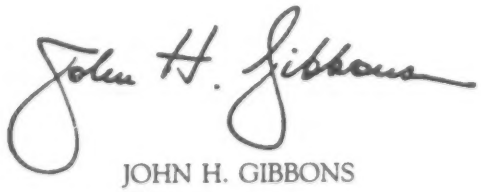
The Technology Assessment Board approves the release of this report. The views expressed in this report are not necessarily those of the Board, OTA Advisory Council, or individual members thereof.

Foreword

Over 1½ billion tons of hazardous materials are transported annually in the United States. Most of these materials reach their destinations safely because it is in society's and industry's best interests to have them do so. We Americans take for granted the convenience of our transportation system and the amenities of modern life that the petroleum, chemical, and nuclear industries help make possible. Sometimes, however, an accident occurs, and a hazardous material is released, causing damage to the public and the environment. The occasional serious accident is both frightening and worrisome, while a disaster, such as the thousands of deaths and injuries in Bhopal, India, and the enormous release of radioactivity at Chernobyl, raises public apprehensions dramatically. Indeed, few activities with such statistically low risks as the transportation of hazardous materials arouse such intense public concern.

The Hazardous Materials Transportation Act, passed in 1975, is the primary Federal law governing this transportation. Largely unchanged in the past dozen years, the Act will be scrutinized carefully by Congress in the near future as it comes due for reauthorization. To determine whether major safety problems exist in the transportation of hazardous materials that should be addressed through legislation, and whether appropriate technologies exist that could improve this essential portion of our Nation's commerce, the Senate Committee on Science, Commerce, and Transportation requested the Office of Technology Assessment to undertake this study. Subsequently, the House Committee on Public Works; the Subcommittee on Commerce, Transportation, and Tourism of the House Committee on Energy and Commerce; and the Subcommittee on Government Activities and Transportation of the House Committee on Government Operations endorsed the study. OTA's report on *Transportation of Hazardous Materials* includes a comprehensive assessment of the regulations, information systems, container safety, and training for emergency response and enforcement for consideration by Congress as it deliberates on reauthorization of the Hazardous Materials Transportation Act.

The advisory panel, workshop participants, and contributors for this study played key roles in developing the major issues and contributed a broad and invaluable range of perspectives. OTA thanks them for their commitment of time and energy. Their participation does not necessarily represent endorsement of the contents of the report, for which OTA bears sole responsibility.



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NOTE: OTA appreciates and is grateful for the valuable assistance and thoughtful critiques provided by the advisory panel members. The panel does not, however, necessarily approve, disapprove, or endorse this report. OTA assumes full responsibility for the report and the accuracy of its content.

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Transportation of Hazardous Materials

Hazardous materials are transported safely every hour of every day. Yet few activities with such statistically low risks arouse such intense public concern. Houston citizens did not remain calm when a speeding truck carrying an intermodal tank of highly flammable methyl methacrylate hit an exit ramp guardrail. The driver was killed. The tank broke open, its contents ignited, and the resulting inferno destroyed part of the freeway and dropped burning debris on the street below. Fortunately, no one else was hurt, and the Houston Fire Department already had a hazardous materials response team with the knowledge and equipment to handle the accident.[1] Denver residents were similarly stunned when a truckload of Navy torpedoes overturned one Sunday morning on a city freeway exit loop. No one was injured, but hours passed before experienced Federal assistance arrived. Worried State and local officials did not know whether the scattered weapons needed to be defused before cleanup could begin.

Although by now most Americans are aware that hazardous materials can wreak enormous health and environmental damage, we continue to take for granted both transportation and the amenities of modern life brought to us by the petroleum, nuclear, and chemical industries. Consequently, spectacular accidents, while relatively infrequent, remind us of the harm that can be done and underscore a demand that something be done to keep them from happening—or at least help us be prepared to handle them safely.

Over 1.5 billion tons of hazardous materials were transported by land, sea, and air in the United States in 1982.* (For a tonnage breakdown by mode, see table 1.) Truck transport, by a fleet of 467,000 trucks, accounts for more than half of all hazardous materials shipments, or about 927 million tons per year. Because this means a great many truck shipments, hazardous materials

[1]Jack Douglas and Dan Grothaus, "Trucker Dies in Fiery Crash," *The Houston Post*, July 31, 1985, p. 1A.

*Based on OTA calculations from data supplied by the U.S. Bureau of the Census and other sources. This does not include pipeline transportation, which would more than double the annual total.

Table 1.—Estimated Transportation of Hazardous Materials in the United States, by Mode in 1982

Mode	Number of vehicles/vessels used for hazardous materials	Tons transported	Ton-miles
Truck	337,000 dry freight or flat bed 130,000 cargo tanks	927 million	93.6 billion
Rail	115,600 tank cars	73 million	53 billion[a]
Waterborne	4,909 tanker barges	549 million	636.5 billion
Air	3,772 commercial planes	285 thousand	459 million
Total		1.5 billion	784 billion

[a]1983 data; 1982 data had too many errors to allow calculations.

SOURCE: Office of Technology Assessment calculations based on Federal data augmented by other resources.

emergency response training is especially important for State and local public safety officers who are usually the first called to an accident.

The types of vehicles carrying hazardous materials on the Nation's highways range from cargo tank trucks to conventional tractor-trailers and flatbeds that carry large portable tank containers or nonbulk packages, such as cylinders, drums, and other small containers. Rail shipments are usually bulk commodities such as liquid or gaseous chemicals and fuels, carried in tank cars. Most hazardous materials transported by water are moved in bulk containers, such as tank ships or barges, while air shipments are typically small packages, often high-value or time-critical material.

People are most concerned about those risks that are involuntary, uncontrolled, unfamiliar, immediate, manmade, and potentially catastrophic.[2] Hazardous materials transportation possesses many and sometimes all of these attributes. Risk assessments can help to address two fundamental questions, one quantitative and objective and one qualitative and subjective:

- What is the level of risk?
- What levels of risk are acceptable to the parties concerned?

The first question is relatively readily addressed with adequate data and proper methodology, although two essential components must be documented—probability and consequence. The second question, however, involves numerous judgments and often a great deal of discussion and negotiation, especially when large numbers of people and several governmental jurisdictions are involved. It is the balance between the answers to these two questions that this report is all about. The Office of Technology Assessment (OTA) can address primarily the first question; decisions about the second fall in the province of public officials at every level of government and citizens across the country.

Public concerns expressed to Congress are rooted in the facts that the level of understanding about hazardous materials transportation in or near a jurisdiction is generally low, and that the technical experts, both industry and Federal regulators, are not trusted to provide complete information about the level of risk or to ensure safety. State and local governments, finding that Federal regulations have not prevented accidents in their cities, have passed legislation requiring permits and fees or restricting hours of travel for hazardous materials, in an effort to control what is perceived to be a substantial public risk. In addition, some large jurisdictions have formed special fire department hazardous materials teams to respond to accidents or spills. Some State and local government and industry groups have united to form a Hazardous Materials Coalition to lobby for greater Federal support for training.

Public apprehensions notwithstanding, most hazardous materials are transported safely to their destinations because:

- Industry—manufacturers, shippers, and carriers —is, for the most part, aware of the dangers of the products and its liability for the personal, property, and environmental damage and expense that an accident could cause and takes appropriate precautions.

[2]N.C. Rasmussen, "The Application of Probabilistic Risk Assessment Techniques to Energy Technologies," *Annual Review of Energy*, vol. 6, 1981, pp. 123-138.

- Hazardous materials transportation is heavily regulated by several governmental bodies.

The basic regulatory structure has been developed, largely by industry, over the last 100 years, and mostly before public awareness of the dangers of toxic substances and understanding of the complex measures necessary to protect public health and the environment reached their present levels. There have been no far-reaching regulatory reforms and no strategic changes to help the system cope with late 20th century technologies and public awareness. For instance, changes in container regulations have addressed individual container designs and specific situations, rather than recognizing that the interaction between container and carrying vehicle has an enormous impact on safety. Although long-established Federal regulations and industry care have helped to maintain the public safety, it is time to modernize our approach and address some of the very real shortcomings in the current system.

More often than not it is people problems (inadequately trained personnel, poor coordination and communication) or lack of information and advance planning, rather than technological shortcomings, that cause accidents, injuries, or environmental damage.* Yet, the roles of the many Federal agencies charged with meeting the complex problems are poorly coordinated and defined. Federal programs that provide technical assistance to State and local governments for emergency response enforcement, accident prevention, and planning activities are uncoordinated, and many find them insufficient and underfunded as well.

The Nation's 39,000 local governments know that their public safety officers will be first on the accident scene and are demanding assistance in being prepared.[3] Differing Federal, State, and local regulations mean that a highway transporter may need to pay four or five different registration fees and have an equal number of permits to complete one shipment through several States.[4] State and local officials find it difficult and sometimes impossible to acquire the basic information on hazardous materials production and transportation that they need to plan and prepare for emergencies.[5] Data available from the Federal Government is disparate, incomplete, and not helpful for these purposes. Moreover, the regulatory process for containers works against innovation in design, thus making the United States less competitive in the international market. In short, the system is burdensome to industry without providing adequately for public health and safety.

The cumbersome system has endured in part because Federal records imply that hazardous materials accident rates are low. However, OTA finds that Federal accident records suffer from significant underreporting and do not provide an accurate assessment of the level of safety in the transportation of hazardous materials. In any case, arguments over statistics are immaterial to the

*Sixty-two percent of reported hazardous materials spills are caused by human error.

[3]Paula N. Alford, National Association of Towns and Townships, "A National Hazardous Materials Emergency Response Fund," unpublished background paper, December 1985, p. 4.

[4]U.S. Congress, Office of Technology Assessment "Transcript of Proceedings—Workshop on State and Local Activities in the Transportation of Hazardous Materials," unpublished typescript, May 30, 1985.

[5]Ibid.

public safety person first at the scene of the accident. He is likely to be one of the Nation's 1 million largely untrained volunteer firefighters and may be confronted with a placarded, derailed railroad tank car spewing a mysterious cloud that burns his eyes.* Chances are his basic training has included suiting up, moving in, and spraying water or foam on such a car. He probably has not heard that the simplest equipment for dealing with a hazardous materials accident includes tennis shoes and binoculars—tennis shoes to run away and binoculars to read the hazardous materials placard from a distance before calling for expert help. He also will not know that State enforcement records show that between 25 and 50 percent of trucks are incorrectly placarded,[6] so if he must respond to a truck accident, accurate identification of the substance involved may be difficult and time-consuming.

Where does the local official look for help in training emergency response people? He could turn to one of four or five agencies in the U.S. Department of Transportation (DOT), the Federal Emergency Management Agency (FEMA), or the U.S. Environmental Protection Agency (EPA). However, the Federal Government offers no guidance about who offers what kind of training or how much it will cost. At the State level, he might seek assistance from the Departments of Environmental Health, Transportation, Public Works, or any of several others, or from the State Fire Marshal's Office. Even if he should succeed in discovering the right group, no funding may be available, and no national training standards have been developed to help choose the appropriate course.

While no national framework for ensuring training exists, all levels of government have a potent tool for dealing with problems/regulations. The massive regulatory code governing the transportation of all hazardous materials except bulk water transport is Title 49 of the *Code of Federal Regulations* (known as 49 CFR). More than 30,000 hazardous materials are subject to these regulations. However, although DOT is authorized to regulate all hazardous materials shipments, and does so for rail, air, and water, it has chosen to exclude intrastate highway transport specifically from regulatory coverage under 49 CFR.[7] In addition, individual States and regional and local governments enact laws, set regulations, and undertake enforcement activities—primarily for the highway mode—that overlap or vary from those set by the Federal Government and by neighboring jurisdictions. The result is a complicated and constantly changing set of controls. Even those Federal officials who write or work directly with the regulations or the memoranda of understanding governing the process can explain only the Federal roles clearly. Hazardous materials enforcement officers and transportation industries—manufacturers, shippers, and carriers—find this welter of regulations inefficient, confusing, and difficult to comply with and enforce.

Moreover, data and information about shipments are so poor and difficult to acquire that State and local regulations are often developed with little or no understanding of the magnitude or nature of the problems to be controlled.

*Emergency response to a railroad accident often involves an industry/railroad response team as well as public response personnel.

[6]U.S. Congress, Office of Technology Assessment, *Transportation of Hazardous Materials: State and Local Activities*, OTA-SET-301 (Washington, DC: U.S. Government Printing Office, March 1986), p. 63.

[7]49 CFR Part 171.1.

For example, gasoline is by far the most frequently transported hazardous material, accounting for almost half of all hazardous materials transported over the highways. Furthermore, almost all gasoline truck trips are local deliveries, making the risk of exposure to the public higher for gasoline than for any other substance. Not surprisingly, therefore, gasoline transport is responsible for more injuries and dollar damages than all other hazardous materials together. Yet State and local transportation restrictions are usually aimed at shipments of hazardous wastes or radioactive materials, which together account for less than 3 percent of all hazardous materials shipments and are already heavily regulated.

This report discusses transportation of all hazardous materials—commodities, radioactive materials including spent nuclear fuel, and hazardous wastes—that travel by truck, rail, water, or air. Pipeline transport is not considered, as its regulation is entirely different from that of vehicles or vessels. One thing is clear—regardless of whether gasoline, anhydrous ammonia, or high-level nuclear waste is being transported, everyone responsible wants to ensure public safety and prevent environmental damage. Disagreements arise primarily over how best to accomplish these aims and how to distribute the costs of the necessary safeguards equitably. OTA has identified four paramount policy issue areas for congressional consideration:

- **Training.**—Development of a national strategy to provide training for State and local emergency response and enforcement personnel. Training guidelines, adequate funding, and providing comprehensive information on existing resources are key components.
- **Federal/State Regulations.**—Greater consistency in Federal, State, and local regulations and enforcement, including extending Federal reporting requirements for hazardous materials releases to intrastate highway transportation. Coordination and cooperation between all levels of government in developing consistent regulations will reduce conflicts and duplication of effort.
- **Public Information.**—Increased availability of information about the transportation of hazardous materials, including spent nuclear fuel. More coordinated Federal data-collection activities would support regulatory decisions and improve public information programs. National guidelines for community right-to-know legislation and Federal assistance for State and local information gathering could be helpful.
- **Containers.**—Better Federal coordination in setting container regulations, including those for spent nuclear fuel. Two areas warrant specific attention: 1) technical requirements, such as changes in gasoline cargo tankers and design tests for spent fuel casks; and 2) operational and procedural practices, such as quality control and industry training.

Underlying these four issues is the lack of clear definition of Federal and State roles and of effective program coordination to make activities more accessible and cost-effective. The basis for many programs to address these issues already exists, but lack of communication and integration between and among different levels of government diminishes their effectiveness.

FEDERAL GOVERNMENT RESPONSIBILITIES

Authority for issuing Federal regulations and developing and implementing programs rests with many different entities. The Federal Government has four roles related to hazardous materials transportation: regulation, enforcement, emergency response, and data collection and analysis. DOT is the lead agency for establishing and enforcing regulations regarding safe transportation of hazardous materials. The DOT Research and Special Programs Administration (RSPA) has authority to issue regulations on many aspects of hazardous materials containers, except for bulk marine shipments, which are regulated by the U.S. Coast Guard. RSPA shares inspection and enforcement activities with the modal administrations, the Federal Highway Administration, the Federal Railroad Administration (FRA), the Federal Aviation Administration, the National Highway Traffic Safety Administration, and the Coast Guard, which also have authority over the vehicles or vessels themselves. RSPA is responsible for identification of hazardous materials as well as:

- regulation of hazardous materials containers, handling, and shipments;
- development of container standards and testing procedures;
- inspection and enforcement for multimodal shippers and container manufacturers; and
- data collection.

Another group of agencies—the Nuclear Regulatory Commission (NRC), EPA, and the Occupational Safety and Health Administration (OSHA)—regulates other aspects of hazardous materials transportation. NRC has jurisdiction over high-level radioactive substances in the civil sector, EPA has responsibilities for chemicals and hazardous nonnuclear wastes, and OSHA is concerned with worker safety. These agencies also undertake training activities and provide technical support for State and local governments.

Three additional agencies have nonregulatory functions related to the transportation of hazardous materials. The U.S. Department of Energy (DOE) will be responsible for high-level nuclear waste movement, storage, and disposal under the Nuclear Waste Policy Act of 1982. The U.S. Department of Defense (DOD) transports many hazardous materials for military purposes. FEMA is responsible for coordinating Federal assistance, planning, and training activities for all types of emergency response with State and local governments. See table 2 for a summary of Federal agency activities.

The data-collection function is similarly spread among Federal agencies, most of which record accidents and spills and monitor compliance and, sometimes, carrier performance. RSPA is the principal agency collecting data on releases of hazardous materials during transportation, but every other Federal entity keeps records pertaining to its area of interest. General commodity flow information is collected by the Bureau of the Census, making possible estimates of hazardous materials flows, and RSPA has made good use of some of the census data for a truck flow study. However, budget constraints at the Bureau of the Census have restricted its data collection considerably, and no additional analysis or exchange of hazardous materials transportation flow infor-

Table 2.—Federal Activities in Hazardous Materials Transportation

	Regulation of:									
	Hazardous materials†	Containers	Vehicles and vessels	Operators	Planning	Recordkeeping	Inspection	Enforcement	Training	Emergency response
DOT:										
RSPA	X	X			X	X	X	X	X	
FHWA		X[a]	X[b]	X	X	X	X	X	X	
FRA		X[a]	X		X	X	X	X	X	
FAA		X[a]	X		X	X	X	X	X	
USCG	X	X[a]	X	X	X	X	X	X	X	X
FEMA					X				X	X
EPA	X				X	X	X	X	X	X[c]
NRC	X	X			X	X	X	X	X	X[d]
DOE	X[e]	X		X	X	X	X	X	X	X[d]
DOD	X[e]			X	X	X	X	X	X	X

KEY: DOT—Department of Transportation; RSPA—Research and Special Programs Administration; FHWA—Federal Highway Administration; FRA—Federal Railroad Administration; FAA—Federal Aviation Administration; USCG—United States Coast Guard; FEMA—Federal Emergency Management Agency; EPA—Environmental Protection Agency; NRC—Nuclear Regulatory Commission; DOE—Department of Energy; DOD—Department of Defense.

†This category includes hazardous substances, hazardous wastes and radioactive materials, and the tools for communication of those hazards such as shipping papers, placarding, and marking.

[a]Package/container design.

[b]In addition, National Highway Transportation Safety Administration issues requirements for new vehicles.

[c]EPA responds to accidents involving the release of products regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and oil spills in coastal and ocean water

[d]Depends on the type of radioactive material, severity of the accident, and the adequacy of State and local response programs.

[e]In cases of national security, DOD and DOE are not required to comply with DOT regulations provided they follow standards affording equal protection.

SOURCE: Office of Technology Assessment.

mation from other agencies is evident.[8] This type of data is essential as a denominator for even crude analysis of accident rates, and its lack is a deficiency in RSPA's planning and regulatory activities.

Perhaps more serious is the lack of interagency coordination for recordkeeping on accidents and releases of hazardous materials. For its own records, RSPA depends primarily on reports filed by mail on its Form 5800.1, which has numerous deficiencies in itself. The databases kept by other DOT modal administrations and the National Transportation Safety Board (NTSB) contain numerous accidents OTA has identified as being related to hazardous materials that are missing from the official RSPA accident file, the Hazardous Materials Information System (HMIS). Although the potential exists for much better data exchange and use, HMIS reporting requirements are so narrow, and data collection and analysis are so inadequate that RSPA has insufficient information to set timely priorities for regulatory actions. Rulemakings are initiated either by petition from industry or an interested party, or are forced on DOT by widespread public concern, often focused through NTSB or Congress. This kind of reactive rulemaking does not measure up to today's needs. Often research or data analysis could have supported the need for change earlier, or the need was documented some time ago—for example, the reclassification of methyl isocyanate from flammable to toxic inhalant—and no action was taken for years.*

The division of responsibilities among multiple Federal agencies and DOT entities developed on the theory that hazardous wastes, radioactive materials, emergency response training, modal safety concerns, and multimodal hazardous materials questions should be addressed by those with appropriate expertise. The Memoranda of Understanding that have been signed between DOT and NRC, EPA, and DOE focus on delegating responsibility under specific laws. Aside from these agreements, there are no formal mechanisms for interagency regulatory coordination, and no attempt at developing a uniform basis for rulemaking or establishing criteria to set rules and standards has been made. Issues that require the coordinated attention of more than one Federal agency, or Federal and State or industry coordination, often take years to resolve, and no effective effort has been made to improve the situation. The one official Federal coordinating group that does exist, the National Response Team, considers primarily emergency preparedness and response activities and has in the past concentrated on managing Federal response. Until very recently, it has done little to define agency roles, diminish the public's confusion, or meet the crying need for State and local emergency response training with vigorous Federal action.

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[8]However, a good deal of analysis related to risk items, such as transporting outdated chemical weapons over different routes, for example, has been carried out at Oak Ridge National Laboratory. S.A. Carnes, et al., Oak Ridge National Laboratory, *Preliminary Assessment of the Health and Environmental Impacts of Transporting M55 Rockets From Lexington-Blue Grass Depot Activity, Anniston Army Depot, and Umatilla Depot Activity to Alternative Disposal Facilities* (Washington, DC: U.S. Department of Energy, November 1985).

*This reclassification was suggested at the Williamsburg Conference sponsored by the National Academy of Sciences in 1980 and was the subject of the U.S. Department of Transportation (DOT) activity in the early 1980s. The effort was dropped, until the National Transportation Safety Board and congressional concern highlighted the issue after the tragic deaths and injuries in Bhopal, India. The subsequent DOT rulemaking was completed in under a year.

Complicating matters further, a number of international regulatory bodies have developed recommendations and standards affecting all modes of transport. Federal regulations are being revised to conform with these international codes, particularly those for the air and water modes. Recommendations for objective performance standards for nonbulk packaging issued by the United Nations Committee of Experts on the Transport of Dangerous Goods have been adopted by many countries. However, DOT has not yet adopted performance standards for nonbulk packagings, even though a proposal has been under consideration since 1982.

The absence of effective Federal program coordination hampers State and local access to available planning, information, and financial resources. Moreover, authority for matters pertaining to hazardous materials rests with a similar variety of agencies in most States. Frequently, responsibility is equally fragmented at the local level. In view of the numbers of agencies and levels of government involved, it is not surprising that hazardous materials transportation safety and training programs and activities, and even some regulations, are uncoordinated, preventing efficient use of already scarce resources.

FINDINGS AND POLICY OPTIONS

Hazardous materials transportation safety is not a local, State, or even national problem only; it has global implications. It is decidedly not a partisan issue, and there is little disagreement on the most important problems. However, finding solutions acceptable to a sufficiently broad spectrum of interested parties to achieve the consensus required for legislation is not easy.

Policy options are clustered around the major issues identified earlier: training for emergency response and enforcement activities, regulatory consistency and reform, data collection and information needs, containers, and cutting across these, Federal programmatic coordination.

Emergency Response Training

Emergency response to hazardous materials incidents is unlike traditional firefighting in that response personnel must identify the specific chemical hazards facing them before approaching an accident or attempting a rescue mission.[9] An inappropriate response to an accident involving unfamiliar chemical products can endanger individuals, the surrounding community, and the environment. Local fire or police department personnel are usually the first to respond to a hazardous materials accident during transportation, and even in a plant, hence their training is of primary importance. Of the approximately 2 million people in the emergency response network, OTA estimates that a maximum of 25 percent have received adequate training to meet a hazardous materials emergency. Training programs are offered primarily by the States or private organizations, and by the Federal Government. Most local response forces have insufficient financial resources to take advantage of available train-

[9]Charles Wright, lecture at Hazardous Materials First Responders Course presented by Union Pacific Railroad and U.S. Environmental Protection Agency Region VII, April 1985.

Photo credit: Research and Special Programs Administration, DOT

Unprotected emergency response personnel in action—a dangerous situation.

ing. The spectrum of local hazardous materials training ranges from well organized and funded hazardous materials courses offered by highly trained individuals to little or nothing.[10]

Of the approximately 1.2 million firefighters in the Nation, 85 percent are volunteers and 15 percent are paid employees of municipal, county, or local governments.[11] However, of the roughly 1,000 persons participating annually in the resident training program in hazardous materials emergency response offered by FEMA at its Emmitsburg, Maryland, training center, 85 percent are paid personnel and 15 percent are volunteer.[12]

According to the National Association of Chiefs of Police, there are between 450,000 and 500,000 local sheriffs and police personnel employed by State and local governments;[13] who are also often called on to provide emergency response. Over 450 training courses in hazardous materials emergency response, planning, and enforcement are available in the Nation, according to a study undertaken at congressional direction by DOT and FEMA in 1985.[14] Costs

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[10]Association of Bay Area Governments, *National Directory of Hazardous Materials Training Courses* (San Francisco, CA: March 1985), p. 8. Data supplied by the International Association of Fire Chiefs to OTA.

[11]Joseph Donovan, National Fire Academy, Federal Emergency Management Agency, Emmitsburg, MD, personal communication, 1985.

[12]James Covington, Hazardous Materials Instructor, Federal Emergency Management Agency, Emmitsburg, MD, personal communication, 1985.

[13]Gerald Arenberg, Executive Director, National Association of Chiefs of Police, personal communication, 1985.

[14]U.S. Department of Transportation and Federal Emergency Management Agency, "Report to Congress: Hazardous Materials Training, Planning, and Preparedness," unpublished draft, January 1986.

for these courses are impossible to isolate, since only aggregate figures are available, but the total dollars spent for training in both emergency response and enforcement, as reported in the Federal study, total $36 million for the 5-year period of 1980-84.[15] While the study did not capture the universe of State and local training, OTA's own research implies that the bulk of the dollars spent have been reported. Moreover, the Federal dollars are of the greatest interest.

The majority of Federal expenditures have been for the longer term, advanced level response training courses of the type offered by FEMA at Emmitsburg. Such courses are appropriate for personnel who will be part of a hazardous materials emergency response team in an area with an identified high-hazard potential, although these represent a relatively small percentage of the Nation's firefighters. The volunteer firefighters and emergency response forces from small urban and rural areas usually have no hazardous materials training at all. Participants in an April 1985 FEMA-sponsored workshop of national, State, and local experts agreed that emergency response personnel in these areas are most in need of training.[16] Moreover, according to a FEMA disaster planning survey,[17] hazardous materials emergencies comprised 4 of the top 10 emergencies considered likely to occur in a community.

OTA concludes that a national strategy to provide an appropriate level of hazardous materials emergency response training, either basic or advanced, to local personnel is an urgent priority. OTA estimates that approximately 1.5 million emergency response personnel need additional hazardous materials training, with the vast majority needing basic first response training. Maintaining the level of expertise through refresher courses for those already trained is also important. Additional expenditures necessary to train 10 to 15 percent of those needing training total $15 to $20 million annually, OTA estimates. This sum could come from a variety of public and private sources, and assumes maximum cooperation between Federal, State, and private groups now providing training and coordinated use of existing training resources, including those of industry. (See table 3.) The Federal role in developing a comprehensive national training strategy, building on existing training resources, could include assistance in preparing training guidelines, helping to ensure adequate funding, and developing a training information clearinghouse.

The problem is not that courses are unavailable, but rather that those who need them are unable to take advantage of them. The reasons are institutional as well as financial. Better organization and utilization of existing resources could improve training delivery considerably. Existing Federal hazardous materials emergency response training and training support programs in FEMA, EPA, the Coast Guard (DOT), NRC, and DOE need to be coordinated and made complementary. They also could be better utilized to meet State and local training needs as well as those of Federal forces.

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[15]Ibid., p. ix.

[16]Robert S. Wilkerson, Chief, Technological Hazards Division, Federal Emergency Management Agency, personal communication, June 1985.

[17]Federal Emergency Management Agency, *Hazard Identification, Capability, Assessment, and Multi-Year Development Plan for Local Governments*, CPG 1-35 (Washington, DC: January 1985).

Table 3.—Calculations for Costs of Hazardous Materials Emergency Response Training for First Responders[a]

Target audience:
First responders—firefighters, police, hospital emergency room staff, and ambulance drivers.

Size of target audience:
1.5 million (approximate)

Nature of training:
Basic training covering identification of hazardous materials, the importance of self protection, protection of the public and environment, and the notification of authorities.

Duration of training:
Modular training geared to appropriate target audiences would be developed and taught by trained instructors. Must provide opportunities for role playing and group problem solving and acquaint response personnel with the unique dangers of hazardous materials response.

Key cost components:
Course development, handout materials/workbooks, instructional services, training personnel, travel, and equipment.

Estimated average cost per trainee:
$100[b]

Estimated trainee completions per year:
150,000 to 225,000

Required annual funding total:
$15 to $22.5 million

[a]This type of training emphasizes the differences between hazardous materials response and firefighting. Training covers the dangers inherent in hazardous materials accidents, how to identify hazardous commodities, appropriate responses, and the application and use of protective equipment. Basic training is not designed to cover advanced hazardous materials response techniques or cleanup procedures.

[b]OTA estimates based on tuition for existing courses and interviews with officials and course instructors. Charges vary widely—one large and successful 2-day program is free, whereas another more comprehensive 3-day course charges tuition of $450.

SOURCE: Office of Technology Assessment.

However, choosing the right agency to coordinate Federal emergency response programs and administer any special funding program is problematic. Institutionally, that agency is FEMA. Yet while there is widespread agreement about the need for a strong, central Federal leadership role in emergency response training, there is equally widespread doubt about whether FEMA can provide that leadership. Moreover, States find FEMA's grant requirements so restrictive that they cannot meet their State's program needs and still qualify for FEMA grants. It is only fair to say that some of FEMA's administrative difficulties stem from the statutory restrictions of the Civil Defense Act of 1950, FEMA's primary source of funds for hazardous materials activities.* However, DOT, EPA, DOE, and NRC have narrower areas of emergency response expertise and their responsibilities for training are focused primarily on Federal response.

One congressional option is to charge the National Response Team with responsibility for coordinating hazardous materials emergency response training and developing guidelines for courses and levels of training using a con-

*The Emergency Management Assistance Program is the vehicle through which States receive funds for activities related to hazardous materials.

sensus process. Congress might wish to designate DOT, EPA, or FEMA, as members of the National Response Team with direct responsibility for training, as lead agency for developing a direct contract program with States for funding training. Funds distributed to States for hazardous materials transportation emergency response training might carry a stipulation that some funds be passed through to local jurisdictions.

Over the past decade, hazardous materials manufacturers have taken steps to address safety concerns. Industry's involvement in hazardous materials emergency response ranges from technical assistance to specialized response teams. Many large petrochemical and chemical manufacturers train and maintain company emergency response teams for both their fixed facilities and transportation accidents. The best known effort is the Chemical Transportation Emergency Center (CHEMTREC), established in 1970 by the Chemical Manufacturers Association (CMA). CHEMTREC staff provide chemical information by telephone for use in onsite decisionmaking and notify manufacturers of accidents involving their products. CMA has also developed the Community Awareness and Emergency Response Program, which encourages industry and community cooperation in the development of emergency response plans. The Channel industries, the Pesticide Safety Team Network, and Chlorep are other examples of cooperative emergency response capabilities provided by industry.

These specialized information and emergency response units were formed by industries to respond to accidents involving their products. With their specialized resources, detailed knowledge of hazardous materials, and extensive product information, industries can provide a logical adjunct to public safety capabilities for fixed facility and hazardous materials transportation emergency response. Furthermore, some industry training resources have been made available to meet State and local needs. A public-private agency cooperative training program has been established by EPA and the Union Pacific Railroad in EPA Region VII. They offer a 2-day training course for hazardous materials identification, free of charge to multidisciplinary groups with emergency response duties.

The most cost-effective training programs are those that use train-the-trainer techniques. These courses also serve as conduits for programs developed according to nationally accepted guidelines. Congress might consider giving funding priority to States whose training officials participate in Federal hazardous materials training programs and subsequently develop State training networks using train-the-trainer courses to improve delivery of training to local emergency response personnel.

OTA concludes that development of national hazardous materials emergency response training guidelines covering course offerings and levels of training is urgently needed by State and local officials. Guidelines for training in equipment use and maintenance would be useful as well. Activities begun this year by the National Response Team and the National Fire Protection Association to develop guidelines are commendable. Broad-based participation of producers, shippers, and emergency response personnel in developing the guidelines is important. At the Federal level, this would mean

that DOT, FEMA, EPA, and probably NRC and DOE need to cooperate and reach agreement, as well as firefighters and other safety groups.

Finally, OTA finds that developing a national clearinghouse to make existing information on hazardous materials training programs and resources available to State and local personnel, both in hard copy and online, would provide an extremely useful service to emergency response forces. The 1985 DOT/FEMA study provides basic information already in computerized form for such a service. Several successful programs exist as models in other areas, most notably, a DOT-sponsored microcomputer information exchange administered through a university.[18]

Training for Enforcement

Consistent, strong enforcement of hazardous materials regulations is a major accident prevention tool. **State enforcement activities have become increasingly important as Federal inspection and enforcement manpower has been reduced.** The number of DOT vessel and vehicle inspections declined in 1984 for every mode except rail, where special congressional appropriations have been made. The DOT man-years devoted to hazardous materials inspections fell from 237 in 1979 to 111 in 1984,* with the most notable decline in the Coast Guard. Appropriations to provide additional support for Federal enforcement have not been forthcoming. However, a DOT-State contract program, the multi-modal State Hazardous Materials Enforcement Development (SHMED) program, helped 25 States develop hazardous materials enforcement expertise and training capabilities. Developed by RSPA through the DOT Transportation Safety Institute, SHMED used home study materials and train-the-trainer techniques to reach large numbers of enforcement and industry personnel in participating States. The program has been both effective and inexpensive; overall expenditures through 1986, when the program expires, will have amounted to just over $3 million.

However, after the SHMED program is phased out, DOT financial support for State hazardous materials enforcement development will continue for motor vehicles only, bolstered by the Motor Carrier Safety Assistance Program (MCSAP), administered by the Bureau of Motor Carrier Safety (BMCS) in the Federal Highway Administration. The MCSAP grant program is designed to improve State capabilities to enforce motor carrier safety regulations, to conduct commercial vehicle inspections both in terminals and along roadsides, and to collect safety data. MCSAP funds may be applied to hazardous materials enforcement activities at the discretion of the State. MCSAP expenditures for 1985 were $14.2 million, and the Secretary of Transportation requested the full funding level of $50 million for MCSAP funds for 1987.

Hazardous materials flow and accident data, poor as they are, show clearly that truck transport has the greatest risk of accidents, and Federal and State inspectors in 1985 pulled out of service for violations an all time high of about

[18]Ron Jensen-Fisher, Project Manager, Urban Mass Transportation Administration, Transit Industry Microcomputer Exchange, personal communication, March 1986.

*Complete 1985 data were not available in time for OTA's report.

40 percent of inspected trucks. MCSAP gives priority to general motor carrier safety programs, justifiably in light of these facts. However, concerns that hazardous materials enforcement activities are being slighted—especially for the rail, water, and air modes—have been raised by many State, local, and industry officials.* **OTA finds that Federal programs developed through the Transportation Safety Institute for enforcement training have provided effective support for State enforcement training needs. In addition, OTA concludes that MCSAP provides essential funding and support for State motor vehicle enforcement and training programs, but that Federal enforcement programs are not adequate for the other modes. If Federal inspections continue to decline, support for development of alternative hazardous materials inspection and enforcement programs for water, rail, and air is needed.**

Responsibility for inspections of container manufacturing facilities might best be left with the Federal inspection forces. The specialized expertise required and the relatively small number of inspections would make development costly for State capabilities to check compliance with container design requirements. Adequate levels of inspection and enforcement, however, even for these targets, would require increased Federal forces. In 1984, for instance, only 144 of the more than 7,000 container manufacturers were inspected by RSPA and FRA, and only 5,220 of the estimated 100,000 shipping facilities were inspected.[19] **Congress might increase DOT's enforcement budget particularly in the areas of water, rail, and air hazardous materials inspections, which are not covered by State enforcement and inspection programs. OTA concludes that Federal inspection forces, which have been halved over the past 5 years while shipments of hazardous materials have been increasing,[20] are now insufficient to ensure adequate inspection levels.** (See table 4.)

*This has been a pervasive theme throughout OTA's information gathering.

[19]U.S. Department of Transportation, *Annual Report on Hazardous Materials Transportation, Calendar Year 1984* (Washington, DC: 1984), p. 42.

[20]Mark Abkowitz and George F. List, "Hazardous Materials Transportation Flow and Incident/Accident Information Systems," OTA contractor report, January 1986.

Table 4.—Hazardous Materials Transportation Inspectors

	1979	1980	1981	1982	1983	1984
Total work-years:						
United States Coast Guard	115.5	115.50	155.76	50.00	40.00	12.0
Federal Aviation Administration	36.9	19.04	17.75	8.20	14.08	15.0
Federal Highway Administration	47.0	49.25	47.25	40.20	25.28	28.0
Federal Railroad Administration	28.2	33.60	34.65	33.00	46.40	48.0
Materials Transportation Bureau (Office of Hazardous Materials Transportation)	9.0	10.00	7.50	6.75	6.75	7.5
Total	236.6	227.39	262.91	138.15	132.51	110.5

NOTE: The term "work-years" refers to the aggregate annual time spent by all inspectors in a mode.

SOURCE: Office of Technology staff—based on Department of Transportation Annual Reports.

Financing Emergency Response and Enforcement Training

OTA finds that the approximately $7.2 million* spent annually for emergency response and enforcement training is insufficient to provide adequate hazardous materials training. While the SHMED and MCSAP programs have provided basic Federal support for enforcement training, emergency response training has not received similar Federal attention. The management of the SHMED program provides a model for a cost-effective federally supported emergency response training program. It made good use of existing resources, provided uniform training, used train-the-trainer techniques, and required that States adopt Federal regulations, designate a State lead agency, and participate in funding. However, total Federal SHMED expenditures were $3 million for a program that reached 26 States, and perhaps less than half the national enforcement officer population of about 500,000; a totally different level of need exists for emergency response training.

OTA estimates that the minimum training time needed for an introductory course for first response to hazardous materials emergencies is 2 days, assuming that the trainees are already trained firefighters, enforcement officers, or medical technicians.** Costs for this basic training depend on where and how it is carried out. Table 3 shows estimates for an annual training program to begin addressing State and local emergency response training needs. **OTA concludes that an annual Federal funding level of approximately $5 to $7 million, added to $10 to $15 million derived from other sources and monies now being spent, could provide adequate Federal assistance, if existing resources are reorganized and tightly managed.**

Possible Federal funding sources include:

- general revenue;
- Federal funding programs related to hazardous materials transportation, such as the Surface Transportation Assistance Act (the fuel tax), the Nuclear Waste Policy Act, or the Comprehensive Environmental Response, Compensation, and Liability Act (Superfund); and
- creation of a dedicated fund based on user fees, such as those generated by a permit or registration fee levied against hazardous materials industries.

The fuel tax is the most broad-based of the three special tax-based funds, and gasoline transport accounts for the largest dollar damages. Since truck accidents require the most frequent emergency response activities, tapping fuel tax funds to support emergency response training provides for a degree of equity. The Nuclear Waste Policy Act provides some funds for State and local activities related to transportation, but such funds are generated by nuclear utilities, and their shipments represent far less than 1 percent of total annual hazardous materials shipments. Superfund already has substantial claims against it and specifically excludes transportation from some programs.

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*Average annual expenditure reported by training organizations in the Department of Transportation/Federal Emergency Management Agency study.

**OTA calculations, based on interviews with emergency response trainers and OTA staff experience with four types of emergency response training: industry, jointly sponsored public and private courses for community first response personnel, Federal training for public response, and Federal training for Federal response.

If used to fund emergency response training, a Federal registration or permit program could have major adverse impacts on similar State and local activities, an issue discussed further in the section on regulatory consistency. Moreover, the administrative costs for such a Federal program need to be carefully considered. **If industry is to support a new user fee to fund training, it will require assurance that:**

- **the amounts assessed relate to the magnitude of local training needs,**
- **the funds reach those most in need,**
- **a fixed limit is placed on the amount it must contribute,**
- **local jurisdictions make maximum use of existing regional resources and participate in the funding effort in some way, and**
- **no individual State or local fee programs are implemented for this purpose in participating jurisdictions.**

Two independent groups have endorsed creation of a dedicated fund, generated by user fees levied against shippers and carriers to support State and local hazardous materials program development and emergency response training. The groups are the Hazardous Materials Coalition, comprised of State and local government organizations and some industry representatives, and the National Hazardous Materials Transportation Advisory Committee, formed by the Secretary of Transportation and comprised of State and local government officials and representatives of industry and labor. Both groups recognize that many jurisdictions already impose registration or permit fees, using them for a variety of purposes frequently unrelated to emergency response, and that requiring payment of another such fee is unacceptable to many industries.* Restrictions on their own fee programs, suggested for jurisdictions choosing to benefit from the Federal fund, may be difficult for States to accept.

Equity in apportionment of funds is an important consideration, although an appropriate basis is difficult to determine. Funds could be apportioned to States on the basis of population or on the basis of hazardous materials transportation density. However, areas such as the Gulf Coast; California; and the Pennsylvania, Ohio, Indiana, and Illinois corridor, which have the largest amounts of hazardous materials traffic, also have the largest number of industry response teams. (See figures 1, 2, and 3.) Moreover, the need for emergency response training is often not recognized in small urban or rural areas, where the probability of an accident is low, but where the consequences of an accidental spill for untrained response personnel could be severe. Finally, jurisdictions that already have well-developed emergency response capabilities have emphasized to OTA that they need financial assistance to maintain training levels and equipment.

Additional local industry involvement in development and delivery of community hazardous materials emergency response training could be encouraged to defray training costs. Support from Federal and private sources for finan-

*Two major industry groups, the Association of American Railroads (AAR) and the Chemical Manufacturers Association (CMA) have opposed such a fund in the past. CMA is modifying its opposition, requesting further study to quantify the need; AAR remains opposed.

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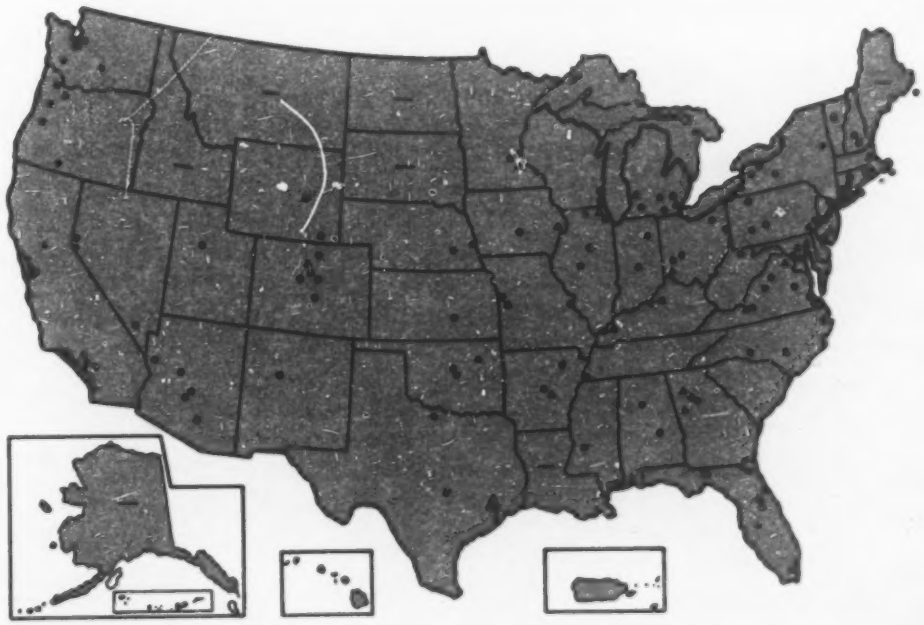
Figure 1.—The Chemical Plants: Where They Are

SOURCES: Environmental Protection Agency, SPN Directory of Chemical Producers, Chemical Week Buyers Guide, Chemsources U.S.A., individual chemical companies.

Figure 2.—Public Hazardous Materials Respose Teams



▲ - County response teams
● - City/town response teams

SOURCE: International Association of Fire Chiefs (IAFC) survey and OTA Staff.

Figure 3.—CHEMNET Emergency Response Team Locations

▲ CHEMNET chemical industry emergency response teams
■ CHEMNET contractor emergency response teams

SOURCE: Chemical Manufacturers Association.

cial assistance to State and local jurisdictions will be more readily forthcoming if jurisdictions can show that they:

- have developed an emergency response plan;
- know what their training needs are;
- have local matching funds or resources available; and
- have cooperated with neighboring jurisdictions in such efforts as joint planning, information collection, and mutual aid agreements.

Regulatory Consistency

The authority granted to DOT under the Hazardous Materials Transportation Act (HMTA) to regulate hazardous materials is comprehensive. However, putting aside questions of whether RSPA has adequate staff for program administration, several decisions made by DOT about how to exercise its authority have limited the applications of its regulations, motivating international organizations and State and local governments to act where they saw a need.

First, DOT has chosen not to apply the regulations to solely intrastate motor transport except for hazardous wastes and substances and flammable cryogenics in portable tanks and cargo tankers.[21] Many public officials, common carriers, and large private carriers that have both interstate and intrastate activities are surprised to learn that most carriers operating solely intrastate are exempt from many DOT regulations. For example a release of a hazardous ma-

[21] 49 U.S.C., Part 171.1 (a).

terial by an intrastate trucking company need not be reported to DOT, and second- or third-hand cargo tankers that no longer meet Federal requirements may be operated within some States. While States accepting MCSAP funds are required to apply 49 CFR in enforcement actions against intrastate carriers, this does not ensure that the reporting requirements and container regulations will be applied.

Second, DOT has not exercised its authority to establish a registration program for shippers and carriers. This has meant that it does not have complete data about the extent of the group it regulates and that the portions of the data that would be useful to State and local officials are not available.

Since the early 1970s, State and local governments have been increasingly active in regulating shipments of hazardous materials to supplement Federal regulations and enforcement and to ensure adequate safety for their jurisdictions. Because each was formulated to meet immediate and separate goals, State programs affecting hazardous materials transportation, like their Federal counterparts, are now characterized by a multiplicity and diversity of activities and areas of jurisdiction. Responsibilities are divided among State utility commissions, transportation, health, environmental, and emergency preparedness agencies. Moreover, great variation among State laws and regulations exists, even though most States have adopted 49 CFR wholly or in part. Finally, the enormous differences in State requirements for truck driver's licenses mean there is no assurance that a qualified driver is behind the wheel of a truck carrying hazardous materials.

Furthermore, finding Federal data lacking in the necessary detail, State and local governments and transportation facilities have enacted a variety of regulations intended to provide information they need for emergency response planning, enforcement activities, and development of local routing restrictions. The result is that shippers and carriers have to comply with multiple State and local registration, licensing, permitting, and shipment notification requirements. Additionally, differing right-to-know laws authorizing public officials to obtain information from facilities within their jurisdictions have been passed at State and municipal levels. The provisions of Good Samaritan laws also vary from State to State; requiring that emergency response personnel, particularly special industry teams that operate in more than one State, be aware of these differences. This wide variation in regulations is clearly at odds with the intent of the HMTA.

Another important regulatory activity of State and local governments is the designation of routes that must be followed by transporters of hazardous materials. Existing highway routing policies established by DOT permit State and local route designations to accommodate local traffic conditions. The Federal highway routing rule for radioactive materials requires the use of Interstate highways or alternate routes designated by State agencies, while a more general requirement for nonradioactive materials instructs carriers to avoid heavily populated areas. Although DOT guidance documents advise States and localities to use explicit safety criteria and involve all affected parties early in making route designations, reaching a consensus is often difficult. In some cases, rerouting has shifted risks to jurisdictions lacking emergency response capabil-

ities; other designations have been contested because affected communities or States were not consulted.

The assumption of greater regulatory and enforcement responsibilities has meant heavier financial burdens for States and localities. Although the SHMED program and MCSAP have provided many States with some funds for the development of hazardous materials enforcement programs, local governments usually do not benefit directly from Federal grant programs to the States. To pay for their inspection, enforcement, or emergency response programs, many States and municipalities require shippers and carriers of hazardous materials to pay a fee when they register or apply for a license or permit. As most State and local fees and requirements apply to highway shipments, the trucking industry has been affected most heavily, and carriers argue vigorously that compliance with differing laws and regulations is time-consuming and expensive.[22] The costs include not only payment of registration, permit, and licensing fees ranging from several dollars up to $1,000 per shipment, but also expenses incurred by special staff to keep track of requirements that continuously change. In addition, carriers point out that certain requirements, such as curfews imposed on some special shipments, cause delays and increase risks. By diverting shipments around their own boundaries, jurisdictions imposing such requirements shift risks to other States and communities.

The roles played by States and localities in the regulation of hazardous materials transportation have grown considerably since the HMTA was passed. The act provided the Secretary of Transportation with broad authority and specified that State and local requirements inconsistent with Federal law and associated regulations should be preempted except under certain circumstances. The legislative history of the HMTA indicates that Congress intended to preclude a multiplicity of State and local regulations, exactly the types of varying and conflicting regulations that now exist. While most State and local governments understand and agree with the need for uniform regulations, especially in areas related to containers and hazard communication, they have also found that DOT activities have not provided adequate safety levels in their jurisdictions. They have thus taken the steps they consider necessary to control the risks associated with the transportation of hazardous materials.

There have been no comprehensive efforts to date to resolve interjurisdictional differences. Resolving questions of inconsistency between local, State, and Federal regulations, a task traditionally left to the courts, has been the focus of an advisory administrative review process, established by DOT in 1976. The 16 inconsistency rulings issued since 1978 indicate that DOT believes that permissible State and local regulatory authority is limited to traffic control and eliminating or reducing safety hazards peculiar to local areas, and that each State and locality must assess the impacts of a requirement, such as a routing rule, on other jurisdictions. However, as the DOT inconsistency ruling process does not preclude judicial review, a number of the cases examined by DOT have also been the subjects of lawsuits.

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[22]U.S. Congress, Office of Technology Assessment, *Transportation of Hazardous Materials: State and Local Activities*, op. cit.

While case-by-case reviews by DOT and the courts are time-consuming and costly, they provide some criteria for assessing the validity of certain types of laws and regulations. However, OTA believes such reviews will not prevent continued adoption of differing State and local requirements, as these provide both needed revenue and valuable data. Any policy or legislative changes to relieve the present situation must address both the financial and informational needs of State and local governments, as well as ease the burden faced by interstate shippers and carriers.

Carrier associations, insurance industry representatives, and State motor vehicle administrators and enforcement personnel have voiced strong support for a national truck driver's license requiring special training. Congress could authorize the development of such a license with special certification requirements for all hazardous materials, including gasoline. Prerequisites for a license should include training and a clean record, and driver certification could be linked to specific types of vehicles. Uniform license requirements and training standards could be developed by DOT, but States would be responsible for issuing licenses and administering the training requirements. State license fees could be set to cover program costs. California has already developed a graded truck driver's license program. A program created by the European Common Market countries requires a hazardous materials driver's license but allows each country to pass its own implementing legislation.

OTA concludes that even if DOT exercised its authority to establish a registration program for its own purposes, the information collected under the program would not completely meet the data needs of States and communities. Thus, **Congress might require development of national guidelines for State information-collection programs in three areas: registration—to determine the number and location of hazardous materials shippers and carriers; licenses or permits—to obtain assurances of fitness from shippers and carriers; and notification—to obtain information on the types of hazardous materials passing through a community or region.** Involving Federal, State, local, and industry representatives in developing both the guidelines and a standard form for requesting information,* would permit consensus and a degree of uniformity. Once States have adopted the guidelines, localities could obtain the information they need from their State agencies. However, bridge and tunnel authorities have special information needs that may include prenotification of certain high-hazard shipments. Assuming that alternative sources of financial support are provided for enforcement and emergency response, State and local fees could be limited to amounts sufficient to cover program administration costs. An annual compendium of State, local, and special authority requirements and contacts would be very useful to interstate shippers and carriers. Industry, DOT, and the States might jointly develop the necessary data for such a compendium.

The broader issue of varying State hazardous materials laws and regulations should also be addressed. Complete information about the scope of existing

*The Uniform Waste Manifest, developed jointly by the U.S. Environmental Protection Agency and the U.S. Department of Transportation, is one possible model.

State laws and regulations pertaining to the transportation of hazardous materials is not presently available. While many States have adopted 49 CFR, some have excluded certain types or quantities of hazardous materials and certain intrastate highway shipments. Conversely, other jurisdictions have established regulations more stringent than the Federal ones. **OTA concludes that an assessment of State hazardous materials laws and regulations to determine whether they are more or less stringent than Federal regulations would be a useful first step toward greater regulatory consistency.** BMCS has already begun, at congressional request, a 5-year study program that will lead to greater highway regulatory uniformity, but only in some areas.[23] BMCS is compiling and reviewing State motor carrier laws to determine those that are more or less stringent than Federal requirements in the areas of driver qualifications and training, hours of service, and equipment maintenance. As part of the process, State laws will be reviewed by a panel convened by the Secretary of Transportation. State laws that are less stringent than their Federal counterparts will be preempted; a law that is more stringent will not be preempted unless it has no safety benefit, poses an undue burden on interstate commerce, or is incompatible with Federal regulations. Another study of State motor carrier laws related to finances is being conducted by the National Governor's Association for DOT. Congress could extend these reviews to encompass State hazardous materials regulations or initiate a separate process. **Congress might also wish to require DOT to reduce emphasis on inconsistency rulings, which are issued after a regulation is in place, and to provide technical and policy assistance to States or communities during the process of developing regulations.**

Congress might also consider requiring the expansion of those parts of 49 CFR promulgated by RSPA, such as reporting requirements and container regulations, to cover all intrastate highway transportation. Such a requirement would allow RSPA regulations to address safety issues more comprehensively. However, if this approach is adopted, States are likely to insist that the same preemption criteria as mentioned above be applied.

Routing is an extremely important accident prevention tool available to State and local governments. Although it is likely that developing a routing scheme that enhances overall safety will be a difficult process for some regions, experience in Portland, Oregon, demonstrates that it is possible. The existing routing regulation for nonradioactive hazardous materials could be amended to provide more explicit guidance to communities. The use of existing DOT routing guidelines, which contain a risk assessment methodology and recommend interjurisdictional consultation, could be required. States interested in designating alternate routes to those approved by NRC for shipments of radioactive materials are already required to follow the DOT guidelines embodied in the ruling known as HM-164. The development of criteria for routing shipments of radioactive and other hazardous materials by rail and water might

[23]This review is authorized by the Motor Carrier Safety Act of 1984, Public Law 98-554, 98 Stat. 2829. State guidelines for compiling, analyzing, and submitting their laws, regulations, and other information were published by the Bureau of Motor Carrier Safety on Jan. 10, 1985 (50 F.R. 1243).

also be considered. **DOT could provide technical assistance to States and communities for applying risk assessment criteria and working through the route-selection process to avert the need for legal action.**

Data and Information Programs

Federal, State, and local governments need data to help them set regulations, plan for emergency response and accident reduction, and target enforcement efforts. Data and information systems pertaining to hazardous materials transportation are kept by many Federal agencies, regional Federal offices, different departments of State governments, and even some local government offices.

Hazardous Materials Flow Information

The most basic data needed for all of these activities are the identities and locations of suppliers, manufacturers, and carriers of hazardous materials. A governmental entity may acquire this information by requiring such firms to register, by conducting an inventory, or by searching existing data. Although it has the authority to do so, RSPA does none of these things and thus has no complete record of the firms it regulates. When they discover that DOT cannot provide them with this important information, State and local governments often impose their own registration requirements or conduct their own inventories. New Jersey and Maryland have completed statewide inventories; Pennsylvania, California, and Denver require registration. The activities, when undertaken by individual States, are costly and time-consuming for both jurisdictions and industry.

To determine what alternative data resources exist at the Federal level, OTA examined current databases. Only one Federal multimodal database exists—the Commodity Transportation Survey, maintained by Bureau of the Census. For a summary of the surveys of data resources on commodity flow, see table 5. The nine regional divisions used in the national databases are shown in figure 4. Highlights of the commodity flow analysis performed by OTA contractors include the following:

- Truck transport accounted for more than 60 percent of all hazardous materials transport (excluding pipeline) in 1982. Gasoline shipments accounted for almost half of the total truck tonnage.
- The average trip length for gasoline trucks was 28 miles, making them predominantly local and intrastate. The average trip length for trucks hauling chemicals was 260 miles, making these trips regional and more likely to be interstate.
- About 90 percent of truck shipments are *intraregional*, as are a high proportion of rail and water shipments.
- The three regions with the greatest concentration of shipments are West South Central, Middle-Atlantic, and South Atlantic (see figure 4), with North Central not far behind.

While these data are instructive in the aggregate, they give State and local planners only some of the information they want about their transportation networks.

Table 5.—Commodity Flow Databases

Databases	Kept by	Years	Modes	Commodity codes	Conversion-table	Strengths	Weakness/drawbacks
Commodity Transportation Survey (CTS)	Bureau of the Census	1977	All	5-digit STCC	Yes	• Multimodal • Consistent selection procedure for all sample data points for all modes • Cross-checked against the census of manufacturers	• Only 5-digit level of commodities • No hazardous materials flags • Only shipments from manufacturing sites to first destinations • Only "principal" mode is reported
Truck Inventory and Use Survey	Bureau of the Census	1977, 1982	Highway	Simple classes	No	• Covers all trucks used in the United States • Contains hazardous materials-related data items • Sample biased toward heavy trucks	• No flow data • Only rudimentary commodity information • Tractor database, not a trailer database—reflects tractor use, not trailer use
Motor Carrier Census	Bureau of Motor Carrier Safety, FHWA	Most recent 5 years	Highway	Hazard classes	No	• Comprehensive listing of carriers and truck fleet operators	• No flow data • Mileage and fleet size data are sparse
TRANSEARCH, FREIGHTSCAN, etc.	Consulting firms	Varies	All	Varies, up to 7-digit for rail	Yes	• Cross-checked against other production/consumption data • Melding of the best available for each mode	• Truck flows predominantly based on the CTS data (see above) • Not in the public domain
National Motor Truck Database	Consulting firms	1977 to present	Highway	Varies, up to 7-digit STCC	Yes, where commodity code is provided	• Focuses on long-distance highway flows • True flow data • Describes the vehicle used to carry the commodity	• Purposely excludes short-haul truck movements, especially in the Northeast • Not in the public domain
Waybill File	Interstate Commerce Commission	At least past 12 years	Rail, TOFC/COFC	7-digit STCC	Yes	• Well-organized sample (1%) of all rail flows • Database is consistent enough to allow trend analyses • Contains some routing information	• Not all hazardous material flows use the special Hazardous Materials STCC

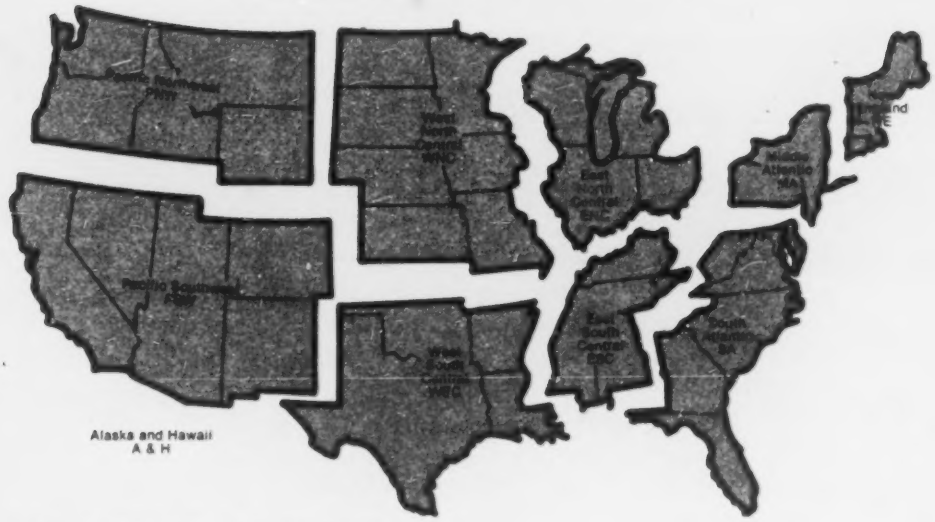
Table 5.—Commodity Flow Databases—Continued

Databases	Kept by	Years	Modes	Commodity codes	Conversion table	Strengths	Weakness/drawbacks
Waterborne Commodity Statistics	Army Corps of Engineers	At least 12 years	Water, domestic and international	4-digit WCSC code	Only to a limited extent	• "100%" sample of all vessel movements • Complete routing information	• Only 163 commodity codes in all, so level of detail is weak • Conversion table has some incorrect cross-references
TRAIN II	Association of American Railroads	Current	Rail, TOFC/COFC	7-digit STCC	Yes	• "100%" data on all movements for participating railroads • Routing information	• Not specifically designed to record car movement histories • Not in the public domain
Hazardous Waste Shipment Data	States, for EPA	Varies	Primarily highway	Either EPA codes or OHMT	No	• "100%" sample of all hazardous waste shipments • Actual flow data	• Many States do not computerize the data • No consistency to commodity code usage • No routing information

ACRONYMS: EPA = U.S. Environmental Protection Agency; FHWA = Federal Highway Administration; OHMT = Office of Hazardous Materials Transportation, Research and Special Programs Administration; STCC = Standard Transportation Commodity Code; TOFC/COFC = trailer on flatcar (piggyback)/container on flatcar; WCSC = Waterborne Commerce Statistics Center (U.S. Army Corps of Engineers).

SOURCE: Office of Technology Assessment.

Figure 4.—Regions Used in This Analysis



SOURCE: Office of Technology Assessment.

OTA finds that Federal data-collection activities are numerous and diverse, each providing modal transportation data of varying completeness. These activities provide useful information on regional flows of hazardous materials transportation, if carefully analyzed, and a sound basis for additional State or local commodity flow data collection. OTA experience in analyzing Federal databases for this report establishes that additional Federal data is unnecessary, that data integration is not a significant technical problem, and that comparative data on commodity flow can be developed.

City officials and planning personnel have been the most vocal in expressing to OTA a need for a national commodity flow data resource. Although an annual printed summary produced by DOT is most frequently mentioned as an appropriate format, some requests have been made for a real-time notification system for especially hazardous shipments. However, emergency response officials consulted by OTA generally prefer to do local inventories and transportation surveys to ensure that their personnel are prepared for any eventuality. They point out that annual summaries describe only last year's shipments and that detailed real-time information would be overwhelming to track and useless for planning and preparedness.[24] As one fire chief said: "What am I supposed to do? Follow the truck around waiting for an accident to happen?"[25] On the other hand, a few local officials and planners want real-time tracking of hazardous materials shipments and have called for the development by DOT of a publicly accessible database to provide this information.[26]

[24]Warren Isman, Chief, Fairfax County, VA, Fire and Rescue Department, U.S. Congress, Office of Technology Assessment, *Transportation of Hazardous Materials: State and Local Activities*, op. cit., ch. 4.

[25]Thomas Hawkins, Jr., Chief, Arlington County Fire Department, Arlington, VA, personal communication, January 1986.

[26]The National League of Cities (NLC) has retained in its transportation position paper a request for a U.S. Department of Transportation report on commodity flow. Barbara Harsha, NLC transportation staff, personal communication, January 1986.

A real-time data system is probably the only way to keep abreast of shipments. Many hazardous materials orders are for truck delivery within 36 hours or less, while other shipments are seasonal, related to agricultural or manufacturing cycles. Finally for economic reasons, customers may change supply sources overnight, rendering periodic data collection instantly obsolete. However, the technological groundwork for a system to track hazardous waste shipments, which represent less than 1 percent of hazardous materials shipments, in real time has been developed by a private firm, although the system has not been tested in operation. Even if the technical difficulties for implementing such a system for all hazardous materials could be resolved, the cost has been estimated to be more than $100 million.[27] **Online telephone access to real-time information on all hazardous materials shipments is neither feasible nor cost-effective, OTA concludes.**

OTA finds that although no current Federal resource can provide shipment information with the specificity desired by State and local jurisdictions, annual DOT summaries of aggregate regional shipments could provide useful regional and State commodity flow data. However, while development of a real-time database to track highly hazardous shipments only is technically feasible, its utility for emergency response is questionable. **Finally, OTA concludes that locally conducted data collection, such as hazardous materials facilities inventories and transportation surveys, is useful and has value beyond the data it produces. The process of gathering information provides data for planning and emergency response purposes and has the additional benefit of acquainting the concerned parties with each other and with the hazardous materials transportation in their areas.** Some Federal financial assistance for State data collection is available through existing grant programs. Community right-to-know laws are useful tools for State and local governments in obtaining data, and national right-to-know legislation would bolster implementation of such laws where industry resistance remains.

If Congress chooses to provide support for data gathering, several options are available. DOT could be required to exercise its authority under 49 CFR, Section 1805(b) and develop a registration program for hazardous materials shippers, transporters, and container manufacturers. **OTA finds that a registration program would provide DOT with essential information about the community it regulates and with general commodity flow information that could be helpful to State and local jurisdictions.** DOT needs the information such a program could provide to help set priorities for rulemaking, research, and enforcement actions. A modest registration fee could be imposed to cover costs of administering the program.

In addition, Congress could require DOT to integrate, analyze, and report annually on trends from relevant Federal databases kept by the modal administrations and the Bureau of the Census. For this effort to be effective:

- the collection of data on truck movements would need to be improved;
- cross-reference keys or bridge tables for the commodity codes used by differ-

[27] John Mulholland, Source Data Network, personal communication, November 1985.

ent agencies and in 49 CFR would need to be created, or each agency might be required to use a common code for commodities; and
- sufficient funds would have to be allocated to support the effort. OTA estimates that the equivalent of one man-year of effort, between $75,000 and $100,000, would provide a modest start.

A summary of the commodity flow data developed in comparison to DOT accident data in the required annual report to Congress would be useful.

Spill and Accident Data

By law, RSPA must report to Congress annually on the safety of hazardous materials transportation, a requirement that, at a minimum, necessitates good records of hazardous materials accidents and spills. A complete safety analysis would also require some reliable estimates of the total amounts of hazardous materials shipped annually by each mode, but as pointed out above, that information is not available.

Hazardous materials incidents or releases,* defined as any unintentional release during interstate transportation, loading, unloading, or temporary storage related to transportation, must be reported to RSPA in writing within 15 days. The written reports serve as the basis for the HMIS, the sole DOT database specifically on releases, casualties, associated damages, and related information on the material, container, cause, and location of the release. All rail, highway, nonbulk water, and air releases occurring during interstate commerce are supposed to be reported on the RSPA Form 5800.1; intrastate highway and bulk marine transport are significant omissions.

Numerous modal hazardous materials release and accident reporting systems had been developed prior to 1971, when HMIS became the official recordkeeping system for release data. The Coast Guard, the National Highway Traffic Safety Administration, FRA, and BMCS, continue to require reports of modal accidents. Coast Guard reporting requirements are particularly extensive, and most water releases are reported to one or another of the Coast Guard systems rather than to RSPA. In addition, carriers are required to make an immediate telephone report to the National Response Center (NRC), staffed 24 hours a day by the Coast Guard, when a release has resulted in serious consequences, such as a fatality or property damage over $50,000, as a direct result of the hazardous material.[28] NRC has two 24-hour toll-free telephone lines to receive notifications, and several other lines to relay calls to emergency response agencies. Carriers involved in a release sometimes telephone CHEMTREC, a chemical emergency center maintained by the Chemical Manufacturers Association. CHEMTREC is required to notify NRC of significant releases; however, a call to CHEMTREC does not fulfill the RSPA written reporting requirements. Despite this, the CHEMTREC toll-free telephone number is the

*Releases are referred to as incidents in 49 CFR reporting regulations. The other release and accident databases studied by OTA all have different definitions of an incident. For the sake of clarity, all Research and Special Programs Administration incidents will be called releases in this assessment.

[28]49 CFR, 171.15.

only telephone number given in DOT's *Emergency Response Guidebook*;* **the NRC telephone number is not listed there.**

Telephone reports received by NRC are logged every evening into a computer at the DOT-Transportation Systems Center (TSC), where the information is retained and managed by RSPA. Nevertheless, RSPA does not include most water releases reported to NRC in its annual report.

Although release reporting is a regulatory requirement, OTA found evidence that the compliance rate is low. The incentive for reporting as required is to avoid the possibility of a civil or criminal penalty; these can include fines ranging up to $25,000 and prison terms of up to 5 years. DOT policy requires consideration of the violator's ability to pay when penalties are assessed. When violators are penalized, the penalty level is frequently too low to deter future violations, because the costs of compliance are greater than those of potential penalties. Thus, some operators consider penalties to be an occasional cost of doing business.[29]

To assess the completeness and accuracy of the HMIS, OTA contractors compared it with relevant Federal modal databases, NTSB data, and State data resources. All of these data resources are available to DOT, with many of them housed at TSC. Through careful analysis of reports filed with DOT modal agencies, OTA contractors were able to determine whether or not hazardous materials were involved in the reported accidents, although data for air shipments are poor. Corrected for duplications and incomplete reports, these comparisons showed that for air and marine transport, the number of releases is underrepresented in the HMIS by factors of 10 and 20, respectively. For rail and Interstate highway transport, the number of releases is underrepresented by factors of 3 and at least 2, respectively. Comparisons of damage estimates in the databases lead OTA to conclude that annual damages are at least 10 times the HMIS figures, averaging more than $160 million a year.**

OTA finds that RSPA has an incomplete record of accidents and releases and has no documentable idea of how much hazardous material is transported. Moreover, RSPA officials regard data collection as a secondary function[30] despite its importance to risk, hazard, and regulatory analysis and to planning for technological and industrial changes. The HMIS is currently an inadequate database. It misses numerous releases recorded in other Federal databases because releases occurring during intrastate highway and bulk marine transportation need not be reported, the reporting requirement is not enforced, and no effort is made to gather accident data other than that reported on Form 5800.1. Augmenting and improving the HMIS need not be extremely costly.

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*The *Emergency Response Guidebook*, developed and widely distributed free by the U.S. Department of Transportation (DOT), gives basic hazard and first response information for hazardous materials regulated by DOT.

[29]National Conference of State Legislatures, *Hazardous Materials Transportation: A Legislative Guide* (Washington, DC: February 1984), p. 36.

**Research and Special Programs Administration reports for 1976 through 1984 included 79,257 incidents resulting in $144,751,240 in damage. OTA calculations adjust this to 178,683 incidents resulting in $1.47 billion in damage for the 9-year period.

[30]Sherwood Chu, Deputy Director, Office of Hazardous Materials Transportation, Research and Special Programs Administration, U.S. Department of Transportation, personal communication, March 1986.

OTA analyses of flow and accident data indicate that relatively few of the HMIS data can be used as indicators, and that a major accident in any single year or on any mode can skew the data significantly. However, **when combined, current Federal accident and release databases provide more comprehensive information on the dimensions of hazardous materials transportation safety problems.** Data results from HMIS that appear to be reliable and are corroborated by other sources include the following:

- the majority of the releases occurred on the highway mode, and most occurred during loading and unloading, rather than over the road;
- corrosive substances have the highest accidental release rate;
- gasoline truck accidents and releases are the most numerous and cause the greatest dollar damage; and
- human error, including speeding and other basic traffic violations, is the leading cause of releases and accidents.

Since trucks carry more hazardous tonnage annually than all other modes together, and there are many more trucks than other vehicles or vessels, the preponderance of truck-related releases is not surprising. A California study, being conducted for the State legislature, compared three separate databases and determined that at least 500 releases occur annually on the State highway system alone, excluding the city streets. Furthermore, the study showed that driver-related factors were the most significant contributory causes in over 50 percent of the accidents.[31] These results imply that addressing issues such as driver qualifications, training, and performance is essential for safety improvements.

In addition, the data show that reported accidents involving hazardous materials more frequently involve common carriers than private carriers and that they occur more often in Pennsylvania, Ohio, Illinois, and California than in other States. Memphis has the highest release rate for the air mode, reflecting the fact that it is a major air freight hub.

The intent of the HMTA clearly indicates the need for an adequate annual summary of the safety of hazardous materials transportation, making improvement to the HMIS an urgent issue. Congress could require DOT to extend accident reporting requirements to all hazardous materials spills over a certain threshold whether they occur during interstate or intrastate transport and regardless of mode. Furthermore, a coordinated national spill reporting center, with reporting procedures and common data report fields that must be implemented by all Federal agencies, could be designated. The DOT National Response Center or the HMIS staff at RSPA provide natural homes for this coordinating role. Moreover, if formats including common data fields were decided on, accident reports collected at the State level could be submitted periodically to the regional DOT or EPA office. The regional Federal offices could provide annual updates to the national center. Several regional EPA offices already work with the States in their regions and have good computerized reporting systems. Reporting requirements need to be more strictly enforced, and release reports should be cross-checked at the regional level for

[31]Linda Turnquist, Analyst, California Transportation (CALTRANS), personal communication, March 1986.

accuracy and completeness before being submitted to a national data-collection center.

DOT could be required to document, in its annual reports to Congress on the transportation of hazardous materials, accidents by State, container types, mode, and cause. Activities now underway at DOT to improve the RSPA spill report, Form 5800.1, and to coordinate with modal administrations to develop common data fields that are less open to subjective interpretation, should make the form reflect more accurately the causes and details of the spill. Congress might wish to require display in the DOT *Emergency Response Guidebook* of the toll-free number for the national report center as the place to call for reporting accidents.

Containers

The Federal regulatory standards for containers used to ship hazardous materials are comprehensive, requiring that the packaging be adequate to prevent release of its contents during transportation. Indeed, standards for containers for highly radioactive materials are set to ensure the packages withstand severe accident conditions without a dangerous radioactive release. To determine the adequacy of the containers used for transportation, OTA studied the accident and release records for the containers, the modal characteristics affecting the choice of containers, and the regulations governing them. The examination included the unique container issues associated with the transportation of radioactive materials, including spent nuclear fuel, as well as packaging for more familiar hazardous materials such as chemicals, petroleum products, explosives, and poisons.

Containers for Radioactive Materials, Especially Spent Nuclear Fuel

About 2.8 million packages of radioactive materials are shipped annually, representing between 2 and 3 percent of the Nation's annual hazardous materials shipments. About two-thirds of these shipments are for medical purposes, with the balance for industrial and research activities and the nuclear fuel cycle.* [32] About 7 percent of all shipments are classified as wastes, with the vast majority being low-level wastes.[33]

While the primary Federal regulatory responsibility for shipments of radioactive materials lies with DOT, NRC and DOE also have specific responsibilities. Under its authority, DOT has issued regulations covering all aspects of transporting radioactive materials, including the containers, the mechanical condition of the transportation vehicles, and the training of personnel, as well as the routing requirements, package labels, vehicle placards, and shipping papers.

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*Shipments associated with nuclear power account for one-twentyfifth of all packages of radioactive materials shipped annually.

[32]Harold S. Javits, et al., *Transport of Radioactive Material in the United States*, SAND84-7174 (Albuquerque, NM: Sandia National Laboratories, April 1985).

[33]U.S. Environmental Protection Agency, "Sources, Amounts and Characteristics of Low-Level Radioactive Solid Wastes," *Low-Level Radioactive Waste Management*, EPA 520/3-79-002 (Washington, DC: May 1979).

Under a Memorandum of Understanding, NRC and DOT cooperate to regulate containers for radioactive materials. NRC, under its own legislative authority, is responsible for regulating, reviewing, and certifying the packaging and certain transportation operations for shipments of fissile and radioactive materials that must be packaged in very secure packages, called Type B containers, when such shipments involve NRC licensees.[14]

DOT sets regulations for all other packaging for radioactive materials in consultation with NRC. NRC approval of routes is required for shipments needing physical protection during transport to prevent theft or sabotage, but the routes chosen must be compatible with DOT regulations.

[14]"Transportation of Radioactive Materials: Memorandum of Understanding," *Federal Register*, vol. 44, No. 128, July 2, 1979. Among the 23,000 Nuclear Regulatory Commission licenses are manufacturers and users of radiopharmaceuticals, oil exploration companies, and nuclear utilities and their supply industries.

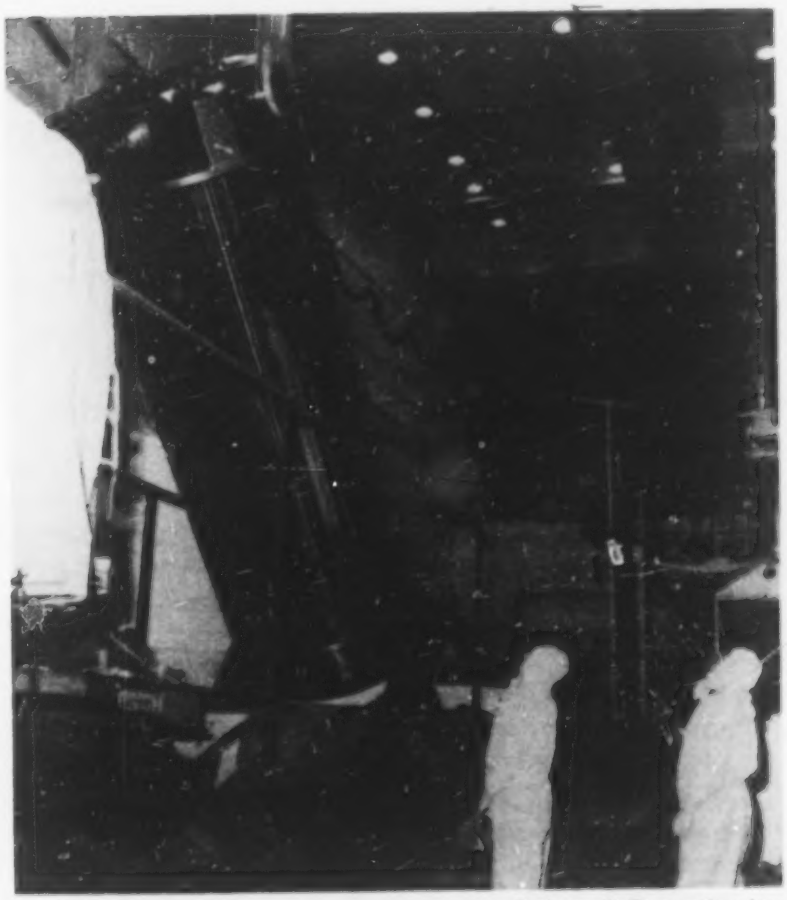

Photo credit: Transnuclear, Inc.

Personnel oversee the loading of the TN8 spent fuel cask, with a capacity of three fuel assemblies, onto a truck bed.

DOE has authority under DOT regulations (49 CFR 173.7) to approve the packaging and certain operational aspects of its research, defense, and contractor-related shipments of materials requiring Type B packages, although DOE is required to use standards and procedures equivalent to those of NRC. **It is in the procedural areas and instances where DOE has chosen to exercise its authority to use containers and procedures other than those certified by NRC that the greatest conflict between DOE and the States has arisen.** For example, officials from New York and New Jersey were outraged to learn in July 1985 that DOE had planned to use a cask that had not been certified by NRC for nuclear waste shipments from Brookhaven National Laboratories on Long Island.

Finally, DOD has separate authority for its radioactive shipments, similar to that of DOE. Three different Federal agencies thus can set standards for shipments of highly radioactive materials; two of them are shippers as well.

U.S. regulations for containers used for radioactive materials transportation are based on internationally accepted performance standards. International regulations and standards divide the materials to be shipped into three categories, based on their radioactivity levels:*

- low hazard or very low levels of radioactivity requiring "strong tight" containers,
- somewhat higher levels of radioactivity requiring secure containers called "Type A" packages, and
- fissile materials and those with very high levels of radioactivity requiring exceptionally durable containers called "Type B" packages.

Federal regulations limiting the radioactive contents for the commonly used strong tight and Type A containers are set on the assumption that the containers might break open in an accident and release some of the contents. In contrast, Type B packages are required to be sufficiently strong to withstand severe accident conditions, thus providing for safety largely independent of procedural and other controls on the shipment. To assure that Type B packages are adequately designed, constructed, handled, and loaded to protect public health and safety, NRC must approve and certify container designs and make certain that quality assurance procedures are implemented for their manufacture, operation, and maintenance. A summary of radioactive materials and packaging types appears in box 1A.

While Type B packages are the first and most important device for public protection, additional regulations and requirements for transportation of spent fuel have been developed. NRC monitors the quality assurance programs of its licensees and requires operational checks, such as leak tests, for the containers prior to each use. NRC checks for compliance with regulations at its licensees' facilities, and its inspectors are on hand to monitor the beginning of any spent fuel shipping campaign. The stringency of NRC inspection and monitoring depends on the inspectors' judgment and confidence in the shipper's quality assurance programs, training procedures and thoroughness in fol-

*International Atomic Energy Agency, Safety Series 6, 1985, now contains a fourth category called "surface contaminated object" which is under consideration to become a U.S. category.

Box A.—Radioactive Materials and Packaging Types

Packages for radioactive materials are chosen based on the form of the material shipped and the degree of radioactivity of the material. There are two forms: normal-form and special-form. Most materials are classified as normal-form. These are not highly radioactive, and although they constitute about 87 percent of all radioactive packages shipped annually, they include only 10 percent of the curies. Special-form materials are generally encapsulated solids that present a hazard due to direct external radiation if they escape from the package. Although they constitute only about 13 percent of all radioactive packages, they encompass about 90 percent of all the curies shipped annually.[1] However, special-form solid material is not readily dispersible and has high physical integrity, and thus poses relatively little risk from inhalation or ingestion. The quantity of radioactivity in the material is indicated by four subdivisions: excepted or limited quantity, low specific activity, Type A, and Type B.

Excepted material is that which is so low in radioactivity that the hazards are negligible, and the materials can be shipped without special packages, shipping papers, or labels. Examples of such materials include smoke detectors, static elimination brushes, lantern mantles, luminous watch dials, and luminous exit signs. Excepted materials are regulated by the Department of Transportation (DOT).

Low specific activity (LSA) material is that in which the specific radioactivity is sufficiently low that the radiological hazard presented by inhalation or ingestion of the material is very small. LSA materials include such things as uranium mill tailings, uranium ore, natural uranium hexafluoride, some low-level wastes, and most laboratory and medical wastes. LSA materials must be contained in strong and tight packages which permit "no leakage of radioactive material under conditions normally incident to transportation." Wooden boxes, 55 gallon drums, and special tank trailers fit this criteria. Containers for LSA materials are regulated by DOT in consultation with the Nuclear Regulatory Commission (NRC). Some LSA materials, such as spent resins from reactors, are required to be packaged in NRC-certified Type A packages.

Type A packaging is intended to prevent the loss or dispersal of its contents when subjected to a specified set of "normal" transportation conditions. The conditions are actually more severe than the "normal" label implies. Most radiopharmaceuticals for medical uses are packaged in Type A containers, as are radioassay materials used in research and medicine, and some wastes associated with reactor operation. Type A containers are regulated by DOT in consultation with NRC.

Type B packaging requirements are the most stringent. Type B containers are employed for the larger quantities and high-level radioactive materials. Type B packages are required for most fissile materials, spent fuel, highly radioactive waste, irradiated components, radioactive sources for medical therapy, industrial radiography sources, highly contaminated equipment, and power sources for pacemakers. Type B "overpacks" are frequently used for shipping many Type A packages when additional protection is required. NRC regulations contain the standards for Type B containers and certifies the designs used in their construction. DOT regulations allow the use of either the U.S. Department of Energy or NRC-certified Type B and fissile packages in commerce.

[1] Harold S. Javits, et al., *Transport of Radioactive Material in the United States*, SAND84-7174 (Albuquerque, NM: Sandia National Laboratories, April 1985).

lowing procedures.[35] NRC also conducts routine transportation checks for compliance with regulations, and in the period from July 1983 to June 1985, inspected more than 300 shipments of spent fuel.[36] As an added precaution, some States through which spent fuel shipments pass require inspection of shipments by State personnel as well.

NRC also requires that the governors of affected States be notified in advance of commercial shipments of spent fuel and certain other highly radioactive materials. The information must include the shipper's name, a description of the material, and estimates of times of arrival at State boundaries. DOE notification procedures are much less explicit, and friction with many States has resulted from this departure from NRC procedures. Moreover, certain shipments that involve national security are exempt from the prenotification requirement.

Both DOT and NRC have the authority to impose fines for violations of regulations. However, the efficacy of the enforcement efforts of both agencies has been the subject of severe criticism. The level of NRC inspection is less a concern than the reliance placed on the judgment of individual inspectors and shipping company personnel. The process provides few outside checks,[37] a situation which under adverse circumstances could have potentially disastrous consequences.[38] Quality control during cask construction, maintenance, and operational checking, and vehicle operations during loading, transportation, and unloading requires vigorous, constant scrutiny to minimize risk and chances of an accident due to human error.

Because shipments of spent fuel, which are made by both rail and trucks, are of special public concern, Congress expressed particular interest in the adequacy of the regulatory standards that must be met by Type B containers. OTA analyzed these standards and shipping procedures in detail. Such shipments represent less than 0.001 percent of the total number of annual hazardous materials shipments, and the probability of an accident involving spent fuel is very low. The potential consequences must be based on technical estimates since no actuarial record exists for such an accident. Currently, somewhere between 100 and 300 shipments of spent fuel occur annually, as utilities shift stored spent fuel from filled cooling pools at one site to other storage pools, or as industry and DOE or DOD move fuel either for storage or research.

Type B Containers for Spent Fuel

The basic criteria for Type B packages, established in 1946 based on recommendations by the National Academy of Sciences, have been adopted by the International Atomic Energy Agency and 53 nations. Current NRC regulations provide a set of performance criteria for the packages, rather than spe-

[35]C. MacDonald in U.S. Congress, Office of Technology Assessment, "Transcript of Proceedings—OTA Workshop on Nuclear Materials Packaging Technology," unpublished typescript, Feb. 8, 1985, p. 142.

[36]Alfred Grella, Office of Inspection and Enforcement, U.S. Nuclear Regulatory Commission, "NRC Inspection Activities on Recent Shipments of Spent Fuel 1983 to Present," unpublished typescript of speech presented at the Spent Nuclear Fuel Transportation Seminar, Chicago, IL, Aug. 1, 1985.

[37]Union of Concerned Scientists, *Safety Second: A Critical Evaluation of the NRC's First Decade* (Washington, DC: February 1985), ch. 4, especially.

[38]Ibid., p. 155.

cific design requirements. These remove the need to predict specific accident circumstances and provide a set of engineering test specifications for impact, puncture, temperature, immersion, and leak tightness that encompass the types of conditions that could occur in an accident.

The most widely recognized Type B containers are the casks for transporting highly radioactive, spent nuclear fuel. Current casks are 10 to over 20 feet long and are constructed of two concentric, welded, stainless steel shells, each typically 1 to 2 inches thick, enclosing a gamma radiation shield of lead or depleted uranium metal and water or other hydrogenous material as a neutron radiation shield. These casks were designed to contain and ship spent fuel that had been removed from the reactor 4 to 5 months previously and that was still relatively radioactive. Potential technical improvements to the casks are examined as a normal part of international research and development and have been a focus of DOE- and NRC-funded research over the years.

The NRC cask certification process is, of necessity, painstaking and time-consuming. The proven safety record of NRC-certified casks, however, provides a degree of public confidence in casks. **OTA finds that technical evidence and cask performance in service indicate that NRC performance standards yield spent fuel shipping cask design specifications that provide for a very high level of public protection—much greater than that afforded in any other current hazardous materials shipping activity. However, meticulous adherence to the designs and specified procedures during cask manufacture and to required safety procedures during loading and transport are critical factors in ensuring public and environmental safety.** Transportation accidents involving shipments of spent fuel will inevitably occur. However, OTA concludes that the probability of an accident severe enough to cause extensive damage to public health and the environment caused by a radiological release from a properly constructed cask is extremely remote. **OTA further finds that fruitful areas for improvements in the overall safety of spent fuel transportation are to be found in the institutional, procedural, and operational controls and arrangements, such as quality assurance and quality control measures; maintenance activities; operator, handler, and driver training; and inspection.**[39]

Finally, OTA finds that continued research is needed in certain technical areas to determine where safety improvements could be effective. Such research needs include: the interface between the carrying vehicle and the casks, such as tiedowns and fasteners; additional and ongoing evaluation of real accident stresses as compared to those specified by the current regulations; and methods of extending accident modeling capabilities to encompass accidents more severe than those currently incorporated in the models.

[39]This aspect was a persistent theme in both the OTA workshop and advisory panel meetings; see for example Richard Cunningham, Nuclear Regulatory Commission, in U.S. Congress, Office of Technology Assessment, "Transcript of Proceedings—Transportation of Hazardous Materials Panel," unpublished typescript, June 27, 1985, p. 230.

Future Spent Fuel Shipments Under the Nuclear Waste Policy Act

Under the provisions of the Nuclear Waste Policy Act (NWPA) of 1982, DOE will take title to spent fuel from commercial utilities and be responsible for its movement, storage, and disposal, starting in 1998. DOE has established the Office of Civilian Radioactive Waste Management to plan and prepare for these activities.

As there will be some 90,000 spent fuel assemblies in U.S. spent fuel pools by that time,[40] DOE may be responsible immediately for a number of shipments to a repository or monitored retrievable storage facility. Depending on the type and carrying capacity of the casks ultimately constructed and certified for these shipments, DOE estimates that approximately 250 rail and 725 truck shipments will be required annually to move spent fuel from reactors in the eastern half of the country to a monitored retrievable storage facility or repository.[41] For NWPA shipments, DOE has agreed to meet DOT and NRC safety and security requirements in effect at the time and will use only transportation casks that have received an NRC certificate of compliance.[42]

A new generation of casks is being designed and tested and will be employed to move spent fuel to a national repository under NWPA. Although they must meet the same performance standards as current casks, the new casks are likely to have somewhat different physical characteristics from those of the current casks, because they will be designed to hold older, less radioactive spent fuel. It is thus likely that the next generation of casks will carry the maximum possible number of spent fuel elements within weight and safety limits, to reduce the number of shipments necessary. Innovations in materials and design have yielded nodular cast iron and monolithic steel casks now used in Europe. Some of these designs have been submitted to NRC for certification and are undergoing testing.

DOE is also examining the possibility of employing very large capacity dual-use casks; these offer an opportunity to minimize both the number of shipments and the handling of the spent fuel. Once the fuel has been removed from the reactor and placed in dry, onsite storage in these dual-use casks, the handling and worker-exposure risk would be reduced if the same casks could be used to transport the spent fuel to a repository. However, the NRC-specified test conditions for casks used for transportation are more stringent than those for storage casks, and although NRC has pending applications for certification of two such casks, none has yet been certified for both purposes.[43]

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[40]George Russ, Atomic Industrial Forum, Bethesda, MD, personal communication, 1985. See also U.S. Congress, Office of Technology Assessment, *Managing the Nation's Commercial High-Level Radioactive Waste*, OTA-O-171 (Washington, DC: U.S. Government Printing Office, March 1985), p. 28.

[41]U.S. Department of Energy, "Environmental Assessment for a Monitored Retrievable Storage Facility," *Monitored Retrievable Storage Submission to Congress*, vol. 2, RW0035, review copy, unpublished manuscript, p. 2.23.

[42]U.S. Department of Energy, Office of Civilian Radioactive Waste Management, Office of Storage and Transportation Systems, "Transportation Institutional Plan," unpublished internal review draft manuscript, Mar. 3, 1986, pp. 3 and D-57.

[43]U.S. Department of Energy, Office of Civilian Radioactive Waste Management, *Annual Report to Congress*, DOE/RW-0004/2 (Washington, DC: March 1986), p. 23.

Moreover, questions will need to be answered about the effects of lengthy onsite storage on the casks' integrity during transportation and on the effects of the large, heavy casks on the stability of the carrying vehicles, whether truck or railcar. The weight would not be a concern if barge transportation were used, but the increased turnaround time required for reusable casks by slower barge travel is an economic trade-off that must be considered.

OTA concludes that once the new casks for NWPA shipments have been developed, and have met NRC certification requirements, full-scale demonstration tests could assist in gaining a level of public confidence. So that their concerns are addressed, organizations and individuals critical of the current transportation procedures should be included in planning for a test. An extensive public information program would be important prior to the test to help affected Indian tribes, public officials, citizens, and safety and emergency personnel understand, to the degree possible, the technical background for the test.

However, considering the technical complexities of the issues, it is wise to be realistic about the extent to which a full-scale cask accident demonstration would increase public understanding. A well-planned, constructed, and staged full-scale demonstration could prove persuasive to many, but no accident demonstration can show all the possible events for all conceivable accidents.[44]

Currently, relations between and among Federal agencies, the nuclear container industry, the nuclear power industry, and State and local governments are strained, as the country struggles to come to grips with the need to dispose of nuclear wastes in a safe manner. The level of public apprehension about shipments of spent fuel requires carefully coordinated programs to address public concerns. Sensitivity to public concerns and programmatic coordination have heretofore not been outstanding at DOE, which will be responsible for NWPA shipments. The technical specifications for the shipping casks are difficult to explain and comprehend, and the stringency of the standards for ensuring spent fuel cask integrity is easily misunderstood. Industry and government will do well to address such apprehensions in a forthright manner. In the meantime, Congress might wish to require DOE to reduce one area of public concern by agreeing to begin using NRC-approved casks and notification procedures immediately for its unclassified shipments. **OTA finds that the parts of the nuclear waste transportation process most in need of change are the institutional attitudes of DOE and NRC and their interactions with the State and local governments and the general public. Comprehensive public information efforts are necessary to address concerns about the level of safety provided by Federal regulations and cask specifications.** Public participation, outreach, and information activities undertaken by the utilities that ship spent fuel regularly provide useful models for programs that DOE, as a future shipper, could develop.

State, local, and Indian tribal officials want to be full partners with the Federal Government in the NWPA transportation planning and decisionmaking

[44]U.S. Congress, Office of Technology Assessment, "Transcript of Proceedings—OTA Workshop on Nuclear Materials Packaging Technology," op. cit., p. 81.

process. In November 1985, DOE sponsored a workshop for State, tribal, and local officials to determine the extent and specific nature of their concerns about DOE's plans for shipments of spent fuel under NWPA. Such activities provide a forum for airing and moving toward resolution of conflicts. **OTA concludes that additional meetings, sponsored jointly by DOT, NRC, and DOE, in cooperation with public interest groups, such as the National Governors' Conference, the National Conference of State Legislatures, the International Conference of Mayors, and the National League of Cities, are essential to informing the public and improving intergovernmental coordination.**

Containers for Hazardous Materials

The packagings or containers used for shipping hazardous materials include tank trucks, railroad tank cars, and barges, as well as bottles, boxes, and drums. They are important factors in transportation safety. RSPA is responsible for issuing packaging and hazard communication regulations for all hazardous materials containers except bulk marine containers, which are regulated by the U.S. Coast Guard, and packaging for highly radioactive materials, for which regulations are developed by NRC.

DOT regulations apply to hazardous materials containers of all sizes, with requirements generally different, depending on whether the material is shipped in bulk or in small packages. DOT marks the dividing line between small (non-bulk) and bulk containers at 110 gallons or 1,000 pounds. Small packages of hazardous materials are carried by water, rail, highway, and air in approved packagings including drums, cylinders, boxes, cans, and bags. Bulk packages generally do not travel by air.

OTA's research shows that hazardous materials packaging generally has been adequately designed. Although there are some problem areas, industry often uses containers more sturdy than required by DOT regulations for very high-hazard materials.

Bulk Packaging

Because accidents and releases in any mode have a common source—human error—the safety records for bulk transport by the highway, water, and rail modes differ, according to the opportunities for error in each mode. Thus, more accidents, spills, injuries, deaths, and property damage occur on highways than on rail or water, in both absolute numbers and accidents per ton-mile traveled,[45] and more occur on rail than on water on a ton-mile basis, due to modal differences in the miles of network, number of operators and individual shipments, traffic densities, and average speed.

Other factors affecting safety include: the extent of coverage by and enforcement of Federal safety regulations for the vessel or vehicle; the amount and quality of training the vessel or vehicle operators and loaders receive; the fre-

[45]A ton-mile is the product of the tons of material carried and the distance carried in miles. For example, a truck with a load of 20 tons that traveled 100 miles would have logged 2,000 ton-miles. Ten trucks each carrying 2 tons and each traveling 100 miles would also have logged 2,000 ton-miles in the aggregate (each truck logging 200 ton-miles).

quency of maintenance and inspections of the vessel or vehicle; and finally, the coordination between the agencies responsible for regulation, inspection, and enforcement activities. Table 6 presents a comparison of modal characteristics for bulk shipping of hazardous materials.

Bulk equipment has a useful life of 20 to 30 years, although maintaining bulk vessels, tank cars, and trucks to high standards can become expensive after the first decade. Because of this long life span, there is little incentive for industry innovation. Changes to the regulations take years to implement, both because the industries involved are economically hard pressed and do not welcome potentially costly changeovers, and because at least two DOT agencies are involved in the decisionmaking process. In times of economic turmoil, such as the transportation industries are now undergoing, fleets may age and deteriorate.

Of the three modes of bulk hazardous materials transport, the highway mode is the most versatile and widely used, carrying over 55 percent of the annual total hazardous materials tonnage. (See table 1.) The nature of the bulk trucking business is different from that of the rail or water modes of bulk transport in that there are many more carriers of a wider variety, and many businesses are much smaller than those typically found in the rail or water mode. The carriers include private interstate carriers; large interstate common and contract carriers; and small common, contract, and private intrastate carriers.*

Tank trucks (or cargo tanks) are the main highway carriers of bulk hazardous materials. Usually made of steel or aluminum alloy, tank truck capacities range from about 2,000 to 9,000 gallons depending on the density, vapor pressure, and corrosiveness of the cargo. In some States, however, which allow higher gross weights, tank trucks may carry up to 13,000 gallons, sometimes in double tanks. Table 7 lists the main contemporary cargo tanks built to DOT specifications and examples of commodities each of them may carry. Older tank trucks built to outdated specifications may still be used to carry hazardous materials, but all newly constructed tank trucks must meet current specifications. These prescribe the thicknesses of the bodies of the tanks, pressure relief devices, manhole covers, gauging devices, overturn protection, pressure test methods, and the like.

Turnover of equipment is slow, and cargo tanks generally go through several tiers of owners. Large private interstate carriers, often large petrochemical companies, have the resources to purchase new equipment and maintain it well. They use their trucks around the clock, 6 to 7 days a week and find it economical to retain tank trucks in their fleets for only 8 to 10 years. Maintenance costs to keep the vehicles up to their standards then become sufficiently high that they sell the trucks to a common carrier or to a jobber and buy new equipment.[46] In contrast, the average tank truck in the fleet of one of the

*Private carriers transport commodities that they own, and the transport is integral to their business. Common carriers are transporters of freight for compensation; common carriers must accept all traffic tendered to them that is within their operating authority (to the extent that they have equipment and drivers to do so). Contract carriers are transporters of freight by motor vehicle for compensation in the exclusive service to one or more specific shipper(s) as authorized by duly constituted Federal or State authority. This classification includes owner-operators under long-term lease to certified carriers.

[46]Clifford Harvison, National Tank Truck Carriers, and E.E. Eigenschenk, Shell Oil Co., personal communications, 1985.

Table 6.—Modal Characteristics of Bulk Shipping of Hazardous Materials

	Highway	Rail	Water
Containers regulated by DOT[a]	Most	All	All
Inspection or testing frequency	Upon manufacture[b]	Upon manufacture plus every 5-10 years[c]	Yearly[d]
Commodity flow data[e]	Very little	Nearly complete	Complete
Regulators and inspectors*	RSPA, BMCS, NHTSA[f]	FRA, RSPA, AAR[g]	USCG, RSPA[h]
Fleet size	130,000 cargo tanks[i]	115,600 tank cars[j]	4,909 tank barges[k]
Fleet database[l]	Partial (BMCS)	Yes, complete (AAR)	Yes, complete (ACofE)
Number of operators[m]	260,000	26,000	45,000
Size of load (gals)	4,000-12,000	10,000-30,000	300,000-600,000

*See table 4 for numbers of inspectors.

[a]Federal regulations cover the transportation of hazardous materials by railcar, aircraft, vessel, and interstate transportation by motor vehicle. Intrastate highway transport of hazardous wastes, hazardous substances, and flammable cryogenics in portable tanks or cargo tanks is also covered (49 CFR 171.1). Unless a State has specifically brought intrastate commerce under regulation, containers in such service need not meet any standards. The Department of Transportation does not know the precise extent to which the States have extended the Federal regulations to intrastate commerce. Most gasoline transport by truck is intrastate and these shipments are a large percentage of the total hazardous materials shipments.

[b]Cargo tanks must undergo an external visual examination every 2 years but generally do not have to be leak tested or pressure tested. However, cargo tanks carrying chlorine must be pressure tested every 2 years and tanks carrying compressed gas (e.g., liquefied petroleum gas) must be pressure tested every 5 years; cargo tanks for flammable cryogenics are inspected prior to each loading. Most tanks, however, are not leak or pressure tested after they are built unless they have been out of service for a year or more, had repairs or modifications performed on them, are operating under an exemption to the regulations, or are used in an area of nonattainment of Clean Air Act standards for ozone. (49 CFR 177.824.)

[c]Tank cars carrying some cargoes are tested more frequently. For example, tank cars carrying chlorine must be tested every 2 years. Also, the frequency of inspection of some tank cars increases to once per year after they are 22 years old. General American Transportation Corp., *GATX Tank Car Manual, 4th Edition* (Chicago, IL: 1979).

[d]46 CFR 31.10-15, and 31.10-17.

[e]Data on the identity and amount of hazardous materials shipped over the highways is collected by the Bureau of the Census every 6 to 7 years, however the quality and comprehensiveness of the data is poor. Records of 80 percent of all rail traffic are kept by the Association of American Railroads (AAR). A record of 1 to 6 percent of all rail traffic is kept by the Interstate Commerce Commission. Records of all origins and destinations of hazardous material cargo that travel on U.S. waterways are kept by the U.S. Army Corp of Engineers (ACofE).

[f]The Research and Special Programs Administration (RSPA) develops and publishes regulations on the cargo tanks. The Bureau of Motor Carrier Safety (BMCS) regulates in-use motor vehicles and drivers, and enforces regulations pertaining to the manufacture, marking, repair, etc., of cargo tanks. The National Highway Traffic Safety Administration (NHTSA) has responsibility for the original manufacture of the vehicle.

[g]AAR establishes the basic technical specifications for tank cars and their running gear. After public rulemaking and comment, RSPA adopts the final specifications in the regulations. Both AAR and the Federal Railroad Administration (FRA) inspect tank cars in rail service. Both AAR and FRA inspect tank manufacturers.

[h]For bulk vessels (tank ships and tank barges), the United States Coast Guard (USCG) establishes the regulations, performs the inspections, administers licenses, and specifies the design of vessels. RSPA sets the standards for intermodal portable tanks that can be carried on container ships and barges.

[i]Estimates from the 1977 Truck Inventory and Use Survey. Of these, 38,000 carry hazardous materials 25 to 49 percent of the time, 14,000 carry them 50 to 74 percent of the time, and 67,000 carry them 75 to 100 percent of the time.

[j]Written communication with AAR. This is about 60 percent of the total number of tank cars.

[k]American Waterways Operators. This is the number of inland tank barges, most of which carry hazardous materials. There are also a small number of ocean going barges and tankers that carry hazardous materials, but tank barges are responsible for most inland traffic.

[l]While the Army Corp of Engineers (ACofE) keeps track of the number of active and inactive vessels that may carry hazardous materials in U.S. commerce, and the AAR's UMLER file lists all tank cars by DOT specification that are in service, there is no comparable database for the highway mode. Although individual companies know how many and what types of cargo tanks or intermodal portable tanks they have, no single agency has an accounting of all bulk highway vehicles nationwide.

[m]"Operator" refers to the vehicle or vessel, "driver." The number of people driving cargo tanks (carrying hazardous materials) is estimated by assuming there are two drivers per cargo tank. Large interstate private carriers often have three or more drivers per vehicle, while other carriers typically have fewer. Information on the rail mode was obtained from AAR and on the water mode from USCG. The number presented in the water mode represents all those licensed by USCG to operate commercial vessels; most of these would not routinely be involved with hazardous materials.

SOURCES: Unless otherwise indicated in footnotes, Office of Technology Assessment, based on information from participants of workshops and panel meetings or comments to draft reports by the affected parties.

Table 7.—Cargo Tank Table

Cargo tank specification number	Types of commodities carried	Examples
MC306	Combustible and flammable liquids of low vapor pressure	Fuel oil, gasoline
MC307	Flammable liquids, poison B materials with moderate vapor pressures	Toluene diisocyanate
MC312	Corrosives	Hydrochloric acid, caustic soda solution
MC331	Liquefied compressed gases	Chlorine, anhydrous ammonia, LPG
MC338	Refrigerated liquefied gases	Refrigerated liquid, oxygen Refrigerated liquid, methane

SOURCE: 49 CFR 172.101 and 178.315 to 178.343.

country's two largest common carriers is now 12 years old, because economic competition is so fierce that, unable to afford major expenditures, companies are keeping their equipment longer. A second tier owner uses a tanker until it becomes uneconomical and then sells it to yet another owner. **This process continues despite the truck's inevitable deterioration, partly because Federal hazardous materials regulations do not generally apply to intrastate motor carrier transport.**[47]

OTA's analysis shows that cargo tank trucks transporting gasoline, about 49 percent of all hazardous materials transported by tank truck, are involved in accidents resulting in more deaths and damages than all other hazardous materials accidents combined. Trucks carrying chemicals represent about 20 percent of tank truck transport of hazardous materials. Of the chemicals, corrosive cargos have the highest accidental release rate per ton-mile[48] and exert the greatest wear and tear on tank trucks. In fact, one safety director told OTA that his acid tanks were ". . . junk after 4 years."

Problems with all varieties of cargo tanks have been studied by DOT over the past 10 years. Study results show that many of the releases from cargo tanks come from discharge valves, pressure relief valves, and manhole covers, and that poor maintenance and inspection of the tanks contribute to the problems. Many parts of a rulemaking proposed by DOT in September 1985 address these shortcomings.[49] **OTA finds that adoption of the proposed changes calling for stringent and more specific manufacturing standards, annual leak testing of all cargo tanks, and stronger manhole covers on gasoline tankers, will improve the performance of cargo tanks.** These actions, while not calling for significant redesign, nonetheless directly address many of the inadequacies uncovered in the DOT studies.

[47]Hazardous wastes, hazardous substances, and flammable cryogenics; and nuclear materials regulated by the Nuclear Regulatory Commission, are the only hazardous materials regulated by the Federal Government regardless of whether the commerce is intrastate or interstate, see 49 U.S.C. 173.

[48]Abkowitz and List, op. cit.

[49]"Notice of Proposed Rulemaking, Requirements for Cargo Tanks," *Federal Register*, U.S. Department of Transportation, Research and Special Programs Administration, Materials Transportation Bureau, Sept. 17, 1985.

Moreover, if registration were required at the time of manufacture of each tank truck built to hazardous materials specifications, subsequent inspections could provide a means of identifying and tracking equipment design and maintenance problems. Release and accident data for the highway mode would be more useful if information regarding container type and primary commodity carried were acquired at the time of registration. Such records are currently kept for bulk marine vessels and railroad tank cars.

Since the early 1980s, when railcars carrying certain hazardous materials began to be equipped with shelf couplers, thermal insulation, and head shields, no catastrophic hazardous materials rail accident has occurred, although there have been numerous accidents and releases. OTA's data analysis shows that corrosives have the highest accident and release rate for commodities carried by rail. Many corrosives such as sulfuric acid and caustic soda are carried in tank car type 111A—the tank car type appearing most frequently in the HMIS. OTA concludes that research to address this issue is important. OTA did not make a detailed study of bulk marine vessels, and the data analysis did not indicate technical problems with bulk marine vessels warranting urgent attention.

OTA finds that countermeasures to address nontechnical issues are important for all modes. Special operator training specifically related to hazardous materials, and training for shipper and carrier personnel responsible for loading and unloading, fastening, blocking, and bracing nonbulk loads, could increase safety substantially. **Congress might consider mandating the development of specific training guidelines, through a consensus process utilizing shippers, carriers, and freight forwarders, as well as government safety personnel, to take advantage of existing expertise and resources.**

Intermodal Containers

Intermodal (IM) tanks are metal containers that hold 4,000 to 6,000 gallons and are surrounded by a metal protective frame that can lock into special fittings on a truck chassis, a railcar, or in a ship's hold or airplane cargo bay. They are versatile and efficient containers for substances that must travel long distances by several different modes. The United States has very few manufacturers of IM tanks, but rapidly growing numbers of these tanks are being transported into and around this country, often over three different modes in a single trip, as international trade increases. The tanks must be registered by serial number with DOT, but regulatory responsibility for them and their carrying vehicles is shared between RSPA and the modal administrations. The poor interagency coordination at DOT is a particularly acute problem for adequate regulation of the transport of these vessels.

The specific areas of concern are the types of chassis used and the method(s) of securing IM tanks onto truck chassis. DOT regulations permit securing the frame of an IM tank to a flatbed truck chassis with chains and hooks called J hooks—a fastening method of questionable reliability, as accident records are beginning to document.

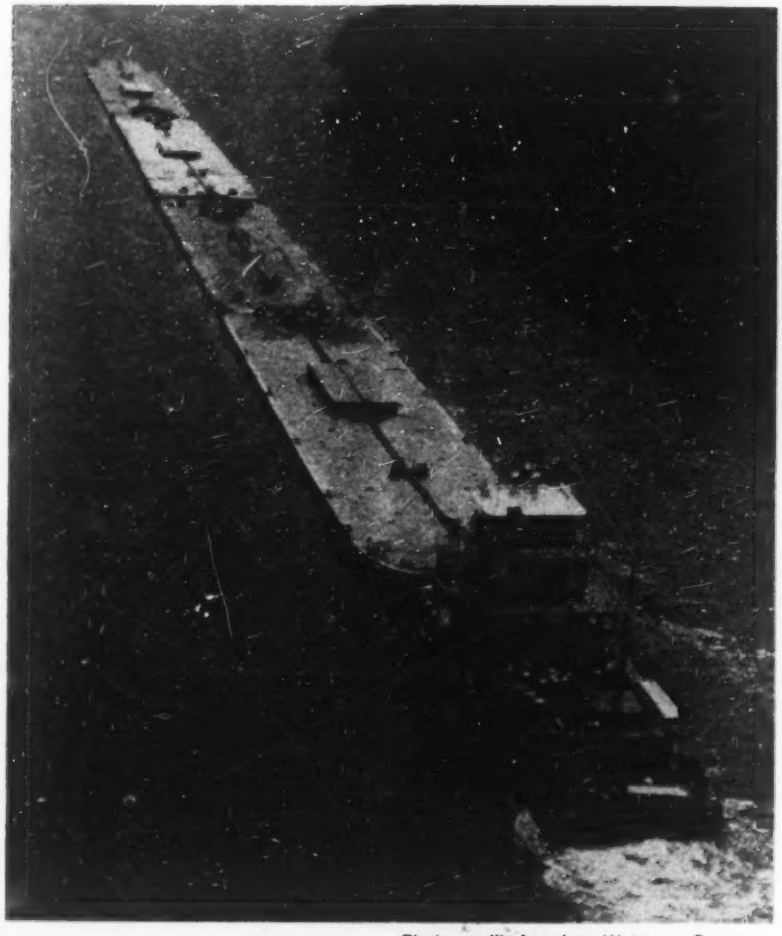

Photo credit: American Waterway Operators

Approximately 35 percent of the hazardous material tonnage transported in 1982 was waterborne.

Few appropriate truck chassis for intermodal tank containers are available in the United States. Most of the chassis available in this country are deficient either in length, securement devices, or overall design, which typically incorporates a high center of gravity. Loaded portable tanks must be carried on 40-foot chassis in order to comply with bridge laws that limit the vehicle weight per axle and per wheelbase. However, only about 400 40-foot chassis in this country have twist locks that positively secure the portable tank to the center of the chassis, preventing lateral or vertical motion, although there are several thousand portable tanks available for commercial use.[50] Thus, most intermodal tank containers now travel by highway on 40-foot flatbed trucks se-

[50]George Graham, President, Chemical Leaman Container Corp., agents for Sea Containers Inc., personal communication, October 1985.

cured by chains, or on 20-foot chassis, which often have proper securement devices, but which violate road weight laws.[51]

In addition, few chassis are specifically designed for intermodal tanks. A "low-boy" chassis, with a centered flatbed several feet lower than normal, lowers the center of gravity and makes the vehicle more stable. Such chassis are used throughout Europe, but there are fewer than 100 in the United States. **OTA finds that immediate and intensive study of the motor vehicle chassis and securement methods for intermodal portable tanks is urgently needed.** The research should be conducted jointly by RSPA, BMCS, and FRA. Congress might wish to require that intermodal tanks travel only on chassis that have twist locks that positively secure the tank against vertical or lateral motion as an interim step.

Small Packaging

Because of the limited amounts of hazardous material contained in small packages, releases generally do not have serious consequences. Release reports for small packages indicate that accidents occur more frequently through mishandling or misuse of the packaging, rather than because of container failure. Air carriers and the U.S. Postal Service reported to OTA that many problems arise from unwitting violations of regulations and mispackaged hazardous materials.[52] **OTA finds that stepping up public information programs and industry compliance training could improve safety.**

Accident and release data are so incomplete that thorough evaluation of the safety record of individual small package designs is impossible. Furthermore, the regulations that govern the packages are lengthy and complex, difficult to understand and follow, and out of harmony with those of our international trading partners.

Performance standards, already in international use for small packages, are likely to be adopted by DOT within the next few years, and the prospective changeover has been widely supported by most of the affected parties. **OTA finds that the new system will simplify the regulations making compliance with them easier, bring U.S. regulations into greater conformity with those of our international trading partners, and make packaging innovations easier and faster to evaluate and implement.** Adoption of performance standards should reduce the time required for the relatively small RSPA staff to handle exemption applications and free them for other functions such as data and trend analysis and planning.

OTA concludes that collection of release data for small packages needs to be improved and continued, so that packaging deficiencies can be identified and remedied, and the adequacy of the performance tests can be evaluated.

[51]George Graham, President, Chemical Leaman Contain Corp., agents for Sea Containers Inc., a major owner, leaser, and transporter of intermodal containers, has strongly advocated that intermodal tanks not be allowed to travel on flatbed trailers secured only by chains. Chains or chain binders allow for tank movement and make the vehicle dangerously unstable. His comments were made at the first semi-annual meeting of the Hazardous Materials Advisory Council, held at Hilton Head Island, SC, Nov. 14, 1985, and reported by Laurie Bradford in "Inexperience Poses Major Threat to Safety in Transport of 'HM,' " *Traffic World*, Nov. 25, 1985.

[52]Steve Gordon, U.S. Postal Service, personal communication, 1986.

Defining Roles and Coordinating Programs

Federal agencies with overlapping interests and responsibilities need to coordinate common activities and define transportation-related policies more explicitly. OTA has identified several areas where specific action would increase effectiveness.

Public concerns related to shipments of spent nuclear fuel are focusing on transportation procedures and safeguards in addition to the containers for spent fuel. Congress might consider requiring DOE, NRC, and DOT to work out notification, State container inspection and other operating procedures, routing, and safeguard policies for NWPA shipments in consultation with each other and in conjunction with State and local officials. **While DOT and NRC both have regulatory roles and DOE is an operating agency, the policies and activities of all three agencies have a single impact on public perceptions.** Moreover, DOT, DOE, and NRC might consider undertaking a joint public information program, using staff specially trained in discussing technical matters with audiences that have widely varying values.

OTA also found that interprogram coordination within DOE has been sadly lacking, although recently, efforts have been made to improve the situation. Staff in offices such as emergency response and transportation often did not know each other and were not familiar with each other's programs. Continued lack of coordination will hamper implementation of NWPA activities and any interagency cooperative efforts.

Finally, Congress could take steps to promote improved coordination within DOT and among Federal agencies. A standing coordinating committee, perhaps under the umbrella of the National Response Team, could be established with representatives from each DOT modal administration, RSPA, other Federal agencies such as EPA, NRC, DOE, and FEMA, State and local governments, and industry. This committee might be required to meet periodically to: define Federal agency missions and roles in the transportation of hazardous materials, coordinate Federal training programs, oversee the development of national guidelines (described above), set a regulatory agenda for intra-agency and interagency issues, and oversee the coordination of common activities such as data collection and enforcement.

Subgroups could be formed to address areas of particular concern. More specifically, DOT and EPA could be directed to develop a joint program to educate small businesses that generate and transport hazardous wastes about DOT transportation requirements and the compatibility of wastes and containers. With more than 60,000 small-quantity generators of hazardous wastes becoming subject to EPA and DOT regulations, the potential for confusion and use of inappropriate containers is immense.

Within DOT, intermodal agency groups could coordinate far more closely. RSPA could take a more aggressive role as DOT hazardous materials coordinator for research and data-collection programs, leaving modal operational details to modal administrations. Federal research on IM tanks is being done separately by modal administrations, when it is being done at all. FRA, for example, is conducting research on the dimensions of intermodal tanks on

trailers and flatcars using truck chassis that violate over-the-road use in most States. Coordination for multimodal research is essential if the work is to be cost-effective. RSPA could act more effectively as coordinator between the Federal Highway Administration, BMCS, and FRA for this effort, to ensure that research results have practical value.

NOTE: Copies of the full report "Transportation of Hazardous Materials" can be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, GPO stock No. 052-003-01042-9.

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